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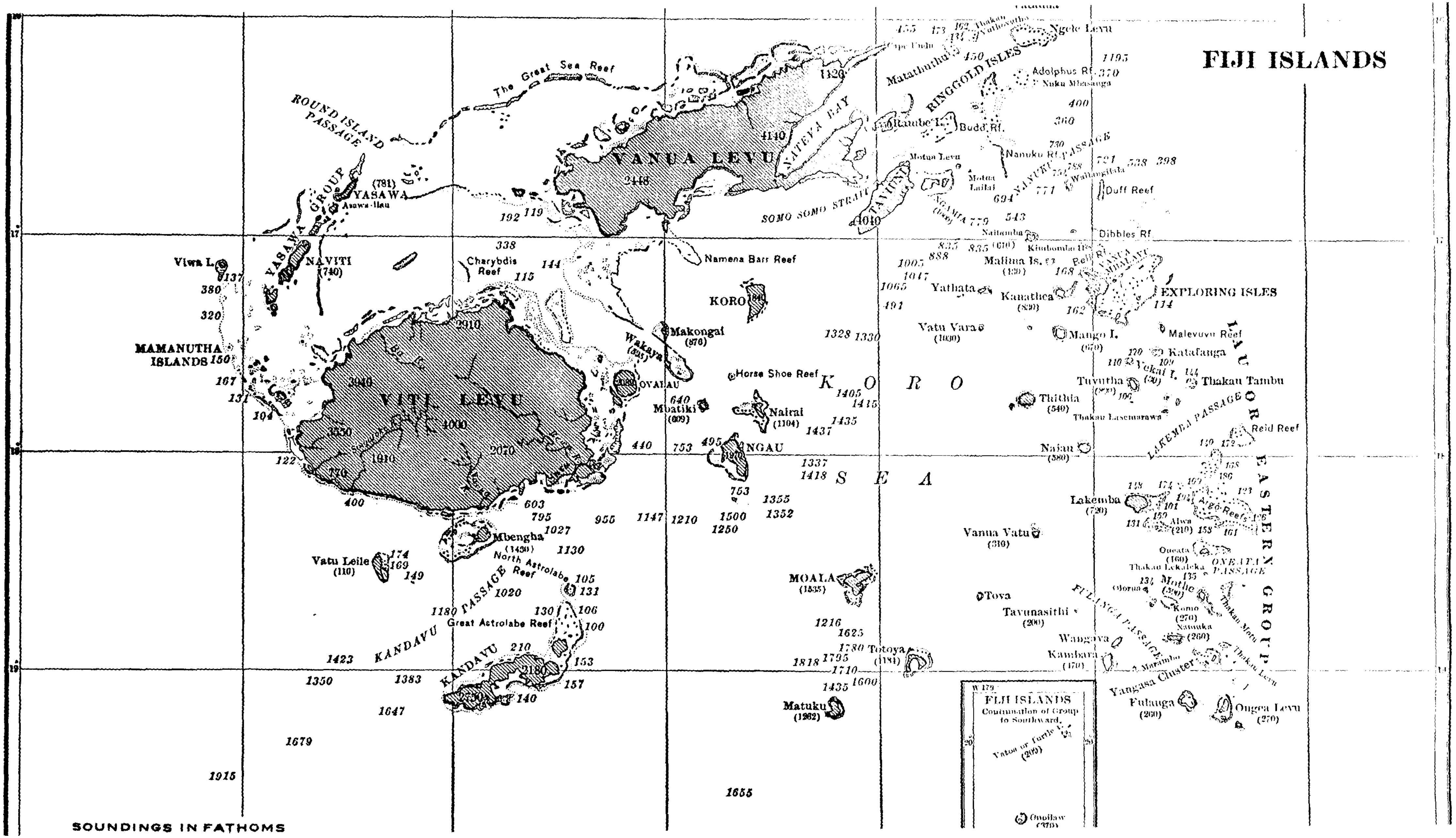
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SHALER MEMORIAL SERIES.

GEOLOGICAL OBSERVATIONS IN FIJI.

By Wilbur Garland Foye.

With One Plate.

Published with Aid from the Shaler Memorial Fund of Harvard University.

GEOLOGICAL OBSERVATIONS IN FIJI.

By Wilbur G. Foye.

PART I.—GEOLOGICAL HISTORY OF FIJI.

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INTRODUCTION.

The difficulty of finding conclusive evidence concerning the nature of the foundations on which coral reefs stand has led to prolonged discussion of the coral reef problem. During this discussion Darwin's theory of the origin of atolls has been the storm center.

The earlier investigators studied the reefs with little reference to the adjacent lands. Among them, Dana (1853, p. 118) alone saw that the reef and the land form back of the reef were intimately connected; that the history of one was written, in part, in the outline of the other. In the last few years, W. M. Davis has emphasized the importance of embayed shorelines behind barrier reefs. The abundance of these features, which Darwin neglected in the announcement of his theory, and the numerous cases of coralliferous limestone resting unconformably on eroded rocks, has led Davis to believe that Darwin's theory is correct.

A luxuriant tropical vegetation has rendered it often difficult to determine the structure of the upraised coral limestones and the nature of their contact with the underlying rocks. It is evident that such data are very important to the coral reef problem. For example, the structure of a reef which develops on an outward-growing platform of its own débris during a stillstand of the ocean level, as postulated by Sir John Murray (1880, p. 517), will not be the same as that of a reef formed on a subsiding volcanic mass, according to Darwin's theory.

With the hope that the study of the structure of the central islands, surrounded by coral reefs, might throw new light on the problem, the writer journeyed to Fiji in June, 1915. This subject as well as other geological problems presenting themselves during the progress of the investigation are discussed in the following pages.

The writer is deeply indebted to the Committee on Sheldon Traveling Fellowships of Harvard University for a generous grant of funds which made the exploration possible. He also wishes to thank the Division of Geology of the University for many kindnesses, especially for a grant from the Shaler Memorial Fund with which to complete the preparation of this report. Nor can he fail to express his sincere gratitude to many friends in Fiji who kindly welcomed a stranger and gave of their time and substance for his aid.

ITINERARY.

After a brief visit to the modern volcanoes of the Hawaiian Islands the writer went immediately to Suva, the capital of Fiji, situated on a beautiful bay at the southeastern side of Viti Levu.

During the latter part of July a brief excursion was made with Mr. Stewart, Assistant Secretary for Native Affairs, to the volcanic island of Mbengha, a few miles southwest of Suva. The beginning of August found the writer en route for the Lau or Eastern group, aboard the inter-island steamer, "Amra." A stop of half a day was made at Levuka, the old capital of Fiji, situated on the volcanic island of Ovalau, near the eastern coast of Viti Levu. Stops of a few hours were also made at Thithia and Mango, but little geological work could there be accomplished.

At Loma Loma, a village on the southeastern side of Vanua Mbalavu, one of the Exploring Group, the writer was cordially received by Dr. St. Johnston, the Government District Commissioner for the Lau Group, and, thanks to letters given by the Honorable Mr. Allardyce, Commissioner of Native Affairs, and the Honorable Mr. Hutson, Colonial Secretary, an extended exploration of this group was made possible. The month of August was largely occupied by a tour of the various islands of the Exploring Group — Vanua Mbalavu, Malatta, Susui, Munia, Thikombia-i-lau, and Avea. An adjacent island to the west, Kanathea, was also visited.

September, October, and part of November were spent in travelling by cutter among the smaller islands south of the Exploring Group.

The Vekai Reef was first visited; then Tuvuthá, Lakemba, Fulanga, Ongea, Vatoa, and Ono-i-lau, the southernmost island of the group. Returning northward, Kambara and Wangava were visited en route for Lakemba. In most cases no more than a day's sojourn at each island was possible, but, owing to the difficulty of obtaining transportation by cutter, a week or more was spent at Ono and two weeks at Lakemba.

From Lakemba, Loma Loma was reached again, and thence by the steamship "Amra," the voyage was made to Taviuni, a large island east of Vanua Levu. The Government physician at Taviuni, Dr. Trotter, gave valuable assistance by furnishing transportation facilities about the island. Leaving Taviuni by cutter the writer saw in the distance Goat Island, lying just off the west coast of Taviuni, and Kioa, an island east of Vanua Levu. Several points on Mbutha Bay, at the extreme eastern side of Vanua Levu, were then visited and a journey made across the Waikava peninsula, forming the extreme southeastern point of the island. This journey allowed 20 to 30 miles of the southeastern coast of the island to be explored; but the isthmus south of Natewa Bay, the long inlet on the eastern side of the island, was not visited. From Mbutha Bay via the island of Rambi the route led to Lambasa, a town on the northern coast of Vanua Levu. At the latter place, the railroad and other facilities, owned by the Colonial Sugar Refining Company, were kindly put at the disposal of the writer and 30 miles of the coast east of Lambasa were traversed, largely by railroad but partly on foot. A walk across the central ridge of the island enabled the writer to see Savu Savu Bay on the southern coast and obtain a clear idea of the geology of the central portion of this island.

On returning to Lambasa, passage was taken in the "Amra" for Suva. The boat touched at Lauthala (a small island east of Taviuni), at Taviuni, and at Levuka. The short voyage from Suva to Navua, a town lying west of Suva, was made by a small launch, running entirely within the barrier reef. After a week's stay at this town, the journey back to Suva was made by launch. From Suva the Government's steamship, the "Ranandi", enabled the writer to reach Lautoka on the extreme western side of the island of Viti Levu.

After a day at Lautoka, Mba, a town some 30 miles north of Lautoka, was reached by railway.

From Mba, the voyage to the Yasawa-Group lying northwest of Viti Levu was made by cutter. During a week's stay in this group, the islands of Nathula, Naviti, and Yasawa-i-lau as well as several small islets, were visited.

Returning to Mba, the entire western side of Viti Levu was traversed by railroad, while the southwestern coast was traversed on foot. A journey of 45 miles inland along the course of the Singatoka River, a river which flows across west central Viti Levu and drains more than a third of the island, led the writer to the plutonic rocks forming a conspicuous part of its central portion. Much of the success of this trip was due to the assistance of the District Commissioner of the Singatoka district, Mr. James Stewart.

From the Singatoka district, Suva and then Kandavu were reached by cutter. Owing to the kindness of Mr. Alcock, the District Commissioner of Kandavu, an extended tour was made possible along the eastern coast of the island, north of Vunisea. Several of the smaller islands, within the Kandavu Reef and north of the main island, were also visited. Among these were Ono and Ndravuni. The small island of Solo, within its own reef, lying north of the Kandavu reef, was the goal of one voyage, whence Vunisea was reached, travelling along the western side of Kandavu.

The writer then returned to Suva, in the middle of February, 1916, and, after a few traverses up the rivers about Suva Bay, sailed for the United States.

PREVIOUS WORK.

Many of the students of the coral reef problem have visited Fiji. Darwin sailed through the group while on his voyage in the "Beagle" but did not land. Dana spent three months among the islands and his results are published as a volume of the report of the United States Exploring Expedition under Commodore Charles Wilkes (1844, pp. 337–352). Professor Dana (1853, p. 135) concluded that while an uplift of 5 to 6 feet characterized the western portion of the group, subsidence had taken place to the east.

About the year 1896, J. Stanley Gardiner (1898, pp. 495–496) of Cambridge University, England, visited a large number of the islands. He concluded that his observations afforded, "strong reasons against Darwin's and Dana's theories of the structure and formation of coral reefs in general and those of Fiji in particular." From a study of the island of Fulanga, one of the eastern group, he was led to believe with Murray that lagoons may be formed "by the wearing and dissolving action of sea water."

In 1897–98, Alexander Agassiz (1899, p. 43) visited the islands in the steam yacht, "Yaralla." He saw evidence of uplift, rather than subsidence, on every side, and was led to abandon Darwin's theory as untenable. He concluded that the coral reefs developed on platforms eroded on uplifted limestone by the action of the sea.

E. C. Andrews (1900) examined the limestones in the field. The island of Mango, one of the Lau group, was studied specially and it was concluded that the volcanic rocks of the island were erupted later than the upraised limestones. The limestones of Vanua Mbalavu were described under two classes: as compact, bedded limestones, and as limestones of reef-rubble origin.

In 1903, W. G. Woolnough (1903, p. 457 and 1907, pp. 431 to 473) made a rapid trip across Viti Levu and was the first to describe granites from specimens collected "in situ."

During the years 1896 to 1899, Guppy (1903) made a very detailed study of the island of Vanua Levu. His chief conclusion was that "Vanua Levu is a composite island built up during a long period of emergence, that began probably in the later Tertiary period, by the union of a number of large and small islands of volcanic formation representing the products of submarine eruptions."

More recently (1914–15), Davis (1915, p. 251) visited the group and described the island of Vanua Mbalavu as an ideal example of a barrier reef formed, according to Darwin's theory, during the subsidence of a central, eroded, volcanic mass.

ABSTRACT.

1. The larger islands of Viti Levu and Vanua Levu have central cores of deeply eroded plutonic rocks and are thought to be remnants of an older continental mass.

2. There have been four periods of vulcanism in Fiji. An early period of rhyolitic eruptivity was followed, without a perceptible erosion interval, by a first period of andesitic eruptivity. After erosion and subsidence, a succeeding uplift was accompanied by a second period of andesitic eruptivity. Erosion and renewed subsidence were followed by another period of uplift initiating a series of basaltic eruptions.

3. There are two series of sedimentary rocks in Viti Levu. The folded series of the interior resemble the folded series of the New Hebrides, which Mawson believes to be Miocene. The coastal-plain series have low dips and, by fossil evidence, are apparently post-Tertiary in date.

4. The uplifted, marine, volcanic rocks of Vanua Levu and the elevated limestones of the Lau and Yasawa islands are held to be Pleistocene or Recent and allied in age to the coastal-plain series. All of these rocks were uplifted without folding.

5. The folding of the rocks of the interior of Viti Levu corresponds to the trend lines discerned by Suess elsewhere in Oceania.

6. As far as observed, the elevated limestones of Fiji rest unconformably on eroded volcanic rocks. They were deposited during the subsidence of eroded volcanic islands and are believed to have formed atolls and barrier reefs.

7. An adaptation of Darwin's theory is especially well illustrated in Fiji, since the earth's crust here has been so unstable. Most periods of subsidence have been accompanied by reef formation.

8. There has been a positive shift of sea-level on many of the islands during late geological time. The two main factors which have produced the shift are subsidence and the return of waters to the ocean after the Glacial period. No criteria have been found to evaluate the relative importance of the two factors.

9. The reduction of masses of elevated limestone to sea-level by atmospheric solution and the submergence of the platforms thus formed have produced conditions favorable to the upgrowth of barrier reefs and atolls.

10. Certain reefs near Suva are growing on the delta flat of the Rewa River, as did other, now uplifted, reefs in a previous epoch.

11. The barrier reefs, east of Lakemba and northwest of Viti Levu, are believed to have developed in part as a result of the downward tilting of the earth's crust in recent times.

12. Limestones, buried beneath volcanic rocks, are exposed at the southeastern side of Kandavu. The erosion types in the island indicate an extended history.

GEOLOGICAL HISTORY OF VITI LEVU.

PHYSIOGRAPHY.

The island of Viti Levu is elliptical in shape. It is 94 miles long from east to west, and 55 miles broad. The southeastern side of the island and a large portion of the eastern side is a low delta flat, overgrown with mangrove bushes. The flat merges into a young, narrow coastal plain which extends from 5 to 10 miles inland where it meets an uplifted mass of marls, a former delta plain now carved into mature hills 70 to 100 feet in height. The older delta plain slopes gradually upward for 5 or 6 miles from its edge, until it rests unconformably against the interior volcanic hills, at heights of 600 or 700 feet.

These volcanic hills form the coast-line for the greater part of the circumference of the island, except near its eastern border. Near the shore the surface is usually maturely eroded, but farther inland various irregular forms, called by the natives spines, thumbs, and twin sisters, give the sky-line a very serrate appearance.

The whole interior is characterized by irregular hills, though quite extensive flats are sometimes found near the rivers. The rocks forming the interior hills are frequently sandstones and marls, in contrast to the volcanic rocks along the coast.

The western and northern shores of the island are very irregular; drowned valleys abound. Many of the valleys are filled with delta deposits, and even small boats find difficulty in entering the river mouths through the tangle of mangroves.

In general the eastern side of the island is well watered; vegetation is abundant. Gorgeous fern forests crown the hilltops, and the higher peaks have giant trees hung with beautiful, trailing mosses.

The western side is usually very dry; trees grow only along the stream beds. An impenetrable growth of reeds covers the hills. The rocks here are deeply lateritized and ravines cut the red and yellow hill slopes.

Western Viti Levu.

Singatoka District.

The Singatoka river has incised a narrow valley in the mature hills of western Viti Levu. Occasional flood-plains border the river, but more often its banks are formed by volcanic hill slopes. In the interior of the island, where loose marls and sandstones abound, flood-plains are much more frequent than nearer the coast where andesitic flows resist erosion.

About 40 miles inland from the southwestern shore of Viti Levu, the Singatoka river and its southern branches cut into a series of plutonic rocks. The central portion of the mass consists of granite and diorite, but near its border there is an ancient, rolling topography carved on gabbroid rocks, which has been flooded by later andesites. Slates and red sandstones were found in the stream beds associated with the diorites and gabbros. One diorite boulder had an inclusion which resembled slate. The actual contact of these rocks was not seen, but, from the inclusion of slate in the diorite, it is inferred that the plutonic rocks intrude the slates and sandstones. The andesites which flooded the gabbro hills were later eroded and depressed beneath the sea. At a water-fall on the northern side of the Singatoka, a coralliferous limestone mingled with pebbles of the andesites lies unconformably on the lava flows. The basal layer is but two or three feet in thickness and grades upward into a sandstone which is overlain conformably by marls and claystones. Occasional beds of brown coal, a few inches in thickness, are interbedded with the marls.

The lava flows represent a thickness of 300 or 400 feet, while the marls and sandstones are 500 or 600 feet in thickness and are overlain conformably by 200 or 300 feet of a massive-bedded limestone. The dips of these rocks are 50° to 85° N., and their general strike somewhat north of east. The limestones are frequently so folded that they are transformed to blue marble. Masses of the limestone form residual, flat tops to many of the interior hills, each covering areas two or three square miles in extent. The sketch shows the rock relations at the contact near the falls. (Figure 1.)

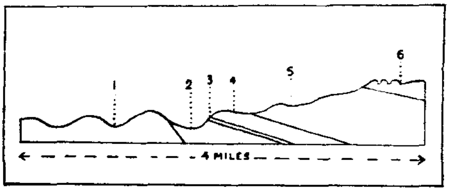

Figure 1. Cross-section of Falls Contact, near Wai Mbasanga, Viti Levu. 1 — Gabbro and syenite hills. 2 — Andesitic flows. 3 — Basal conglomerate (2 feet) with coral heads. 4 — Marl. 5 — Claystone and marl with occasional brown coal seams. 6 — Massive limestone.

About 12 miles from the present southwestern coast-line of the island, near the small town of Tumbairata, the rock types just described disappear and volcanic agglomerates and ash-beds replace them. No contacts were seen, but as the dips of the ash beds were low, in contrast with those of the folded sediments, it was inferred that the andesitic agglomerates were more recent than the marls and sandstones of the interior.

Seven miles from the coast, near Narata, a boulder conglomerate, with pebbles and boulders 12 to 14 inches in diameter, was found. The boulders are largely of andesitic material, very rarely of limestone. There is little paste in the conglomerate but occasional layers of gravelly sandstones are interbedded with it. These beds dip 8° to 10° S. While no contacts were seen, it is reasonable to suppose that the conglomerate was eroded from, and overlies, the agglomerate and limestone formations which outcrop on the north. From this point southward, sedimentary rocks occur which have the same general character as those found at Narata, save that the size of the grain becomes smaller and smaller as one approaches the sea. At Yalava, gravel deposits appear; at Tusuirewa, three miles from the mouth of the river, the rocks exposed are marls and sandstones. All these deposits have low dips and form part of an old, uplifted coastal plain.

Near the mouth of the river and for several miles along the coast on either side, there is a series of maturely eroded hills of deeply lateritized andesitic flows and agglomerates. About these andesitic masses, the sandstones and marls of the ancient coastal plain were deposited and later were partially eroded away. At present, coral limestones, which were formed in the quieter waters off the ancient shore-line, cover the hills near the sea; farther inland sandstones and marls occur.

Coral limestones, interbedded with marls and fine conglomerates, are found along the coast for 15 or 16 miles on either side of the mouth of the Singatoka river. The limestones form lenticular beds which often pinch out abruptly. They appear at elevations up to 150 feet and are extensively eroded.

About 12 miles west of the Singatoka, at the little town of Na Sana Sana, a diabasic dike, five feet in width, cuts the limestone. There has been igneous activity, therefore, subsequent to the formation of the narrow coastal plain.

The accompanying sketch (Figure 2) illustrates the topography at the mouth of the Singatoka river. A low point of coralliferous limestone juts out from the eastern bank. The limestones rise 75 feet on the side of an andesitic hill, a quarter of a mile back from the shore, from which the sketch was made. To the west, rolling sand hills, approximately 150 feet in height, extend for two or three miles along the coast. The dunes are travelling westward.

The conditions here are very different from those found at the mouth of the Rewa. The latter river drains a volcanic country, and the lateritized clays are swept down in great abundance. The mouth of the river is a wide mud-flat overgrown with mangrove bushes. The Singatoka, on the other hand, drains a region of granites, diorites, and sediments formed from these rocks. The material, transported by the river, is, therefore, less finely pulverized and is not carried far out to sea. It is also less cohesive above the low-tide mark, dries out quickly, and is blown by the wind into sand hills. Under such conditions corals grow close to the mouth of the Singatoka and, as the sketch shows, the boat passage is very narrow, being kept open only by the scour of the river and tidal currents.

Figures 3 and 4 indicate the areas of marl and coralliferous limestone forming the upraised coastal plain along the southwestern shore of Viti Levu. The belt is never very wide, varying from a half mile to two miles. At the extreme southwestern point of the island, near the small island of Songo, the deposits cease, and it is important to note that here the fringing reef changes to a barrier reef and sweeps out beyond the volcanic islands of the Malolo Group.

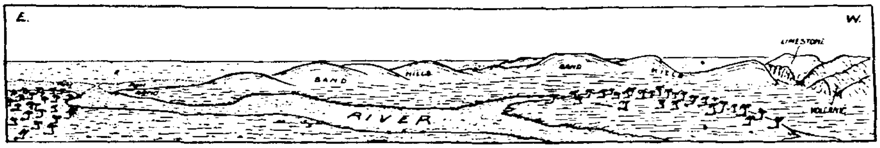

Figure 2. Mouth of the Singatoka River as seen from the Northeast.

The depth of water within the Malolo lagoon, back of the reef, gradually increases toward the northwest, from 13 fathoms to 40 and 50 fathoms. The character of the reef correspondingly changes. Near the main island it is quite continuous; farther northwest it becomes more and more patchy and at last disappears entirely.

At first, one might be tempted to correlate the uplift of the coastal sediments east of Songo with the general subsidence to the west, which has embayed the western coast of Viti Levu, thus regarding these movements as part of a single warp affecting the whole island within recent times. Structural evidence from the western coast of Viti Levu and from the Yasawa islands shows that the formation of the lagoon and the barrier reef cannot be ascribed to a single tilting movement toward the west.

It is true that the western coast of the large island is deeply embayed, but there has been uplift along this coast since the embayment. The Nandi River, for example, has a wide, alluvial valley extending for 8 miles inland. Near its mouth, residual hills rise 60 to 75 feet above the general level of the plain. Some of these hills are composed of a red clay, the lateritized product of andesitic rocks. Other hills are made of loose river gravels which unconformably overlie the volcanic rocks and must have been uplifted recently. Again, masses of uplifted coral limestone exist at the northwestern side of the lagoon, among the Yasawa islands. The positions of the masses cannot be accounted for by a single tilting movement.

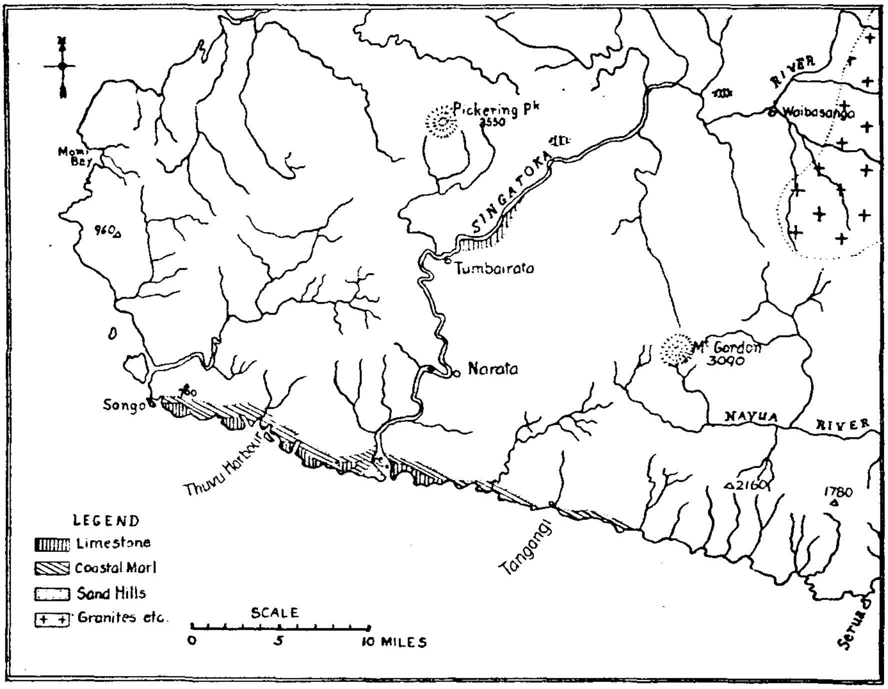
Momi Bay
960
Pickering Pk
3550
SINGATOKA
RIVER
Waibasanga
Tumbairata
Narata
Mt Gordon
3090
NAVUA
RIVER
Songo
780
Thuvu Harbour
Tangangi
2160
1780
Serua
LEGEND
Limestone
Coastal Marl
Sand Hills
Granites etc.
SCALE
0
5
10 MILES

FIGURE 3. Geological Sketch Map of Southwestern Viti Levu.

A study of the recently established shore-line of southwestern Viti Levu and the older, eroded topography of the limestones of the

Yasawa group and eastern Viti Levu, near Suva, has led the writer to postulate the following history for Malolo lagoon and reef.

1. The lagoon was initiated by the extensive submergence of Viti Levu during the period in which the coastal-plain sediments were deposited. The sediments formed a wide submarine flat about the older, folded mass of the island.

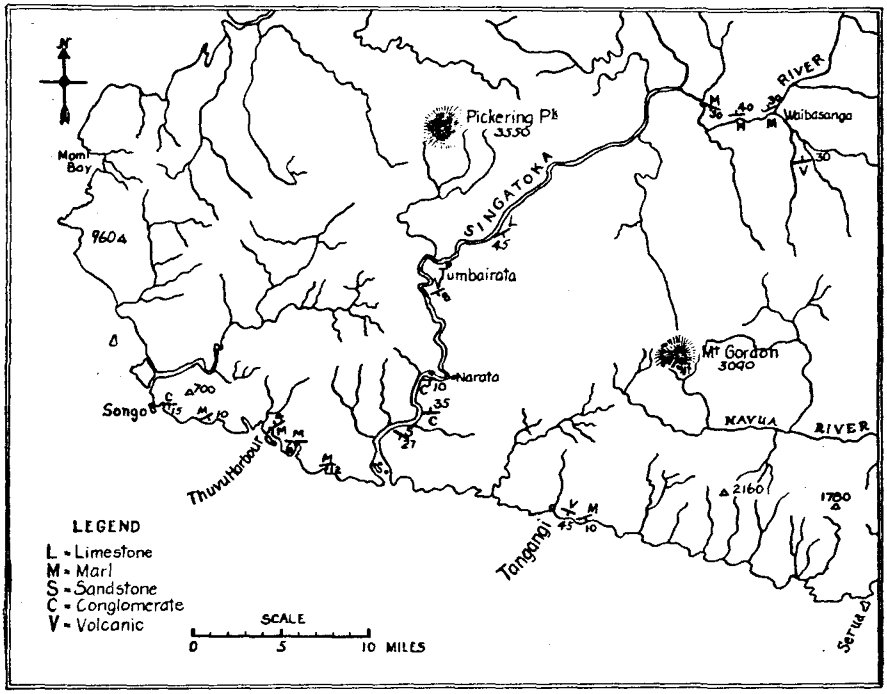
N
Pickering Pk
3550
SINGATOKA
RIVER
M 30
40
30
M
M
Waibasanga
30
V
Momi Bay
960
L
45
Tumbairata
Narata
C 10
35
C
27
Mt Gordon
3090
NAVUA
RIVER
C
700
Songo
15
M 10
Thuvu Harbour
M
M
M
S
2160
1700
Tongangi
V
M
45
10
Serua
LEGEND
L - Limestone
M - Marl
S - Sandstone
C - Conglomerate
V - Volcanic
SCALE
0
5
10 MILES

Figure 4. Structural Dips in Southwestern Viti Levu.

2. The western portion of the flat was then warped in such a way that the Yasawa limestone was raised above the sea, forming the western side of a trough. The western rivers of Viti Levu, draining into the eastern side of the trough, were drowned by local subsidence and a contemporaneous upwarp caused the emergence of the coastal series at the eastern side of the island, near Suva.

3. A period of erosion followed, after which volcanoes developed

within the Yasawa group burying with their ash the eroded limestones of that area.

4. The volcanic cones were then eroded to sub-maturity and in comparatively recent times have been submerged.

5. The uplift of the Nandi river gravels and of the coastal series near the mouth of the Singatoka river in southwestern Viti Levu occurred during the recent submergence of the Yasawa islands.

There has been, therefore, a slight tilting of the lagoon in recent times towards the northwest, but the lagoon and its bordering reef did not originate with this movement. It is a much older feature.

Yasawa Group.

Lying along the western edge of the lagoon which has just been described is a series of islands the southern members of which are known as the Malolo group, and the northern, as the Yasawa group. Most of these islands are composed of andesitic rocks, sub-maturely eroded. Their coastal outlines offer some of the best examples of embayed topography to be seen in Fiji.

A few of the islands contain elevated limestones, the rocks of special importance in the present investigation. Viwa, the most westerly island of the Fiji Archipelago, is low, flat, and composed of upraised coralliferous limestone with a central hill about 20 feet in height. Lacking means of visiting this island, the writer devoted his time to the two other islands showing coralliferous limestone, namely Nathula and Yasawa-i-lau.

Nathula, one of the northern islands of the Yasawa group, has a rough interior of elevated peaks bounded by sheer cliffs. Its coast-line is very irregular and is fronted by numerous dismembered islets. At its extreme northern end, a small area of sandy limestone was found to contain pelecypod shells and coral, mingled with blown, angular bits of andesitic glass and augite crystals. The area forms a point not over an acre in extent. The limestone has a dip of 25° E. and is much brecciated, owing to the intrusion of a fine grained dike of andesite (Figure 5).

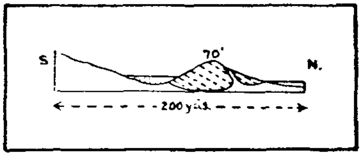

FIGURE 5. Cross-section of the Northern End of Nathula, Yasawa Group.

White—intrusive basalt. Dashed—elevated limestone. Dotted—sandy flats.

A few isolated islets of limestone, on the north, connect this point with the larger island, Yasawa-i-lau, which is entirely composed of limestone. It is about 700 feet high and is honeycombed with a network of caves, many of which extend below sea-level and in which the tide rises and falls. The adjoining sketch of the island was made from the northern side of Nathula (Figure 6).

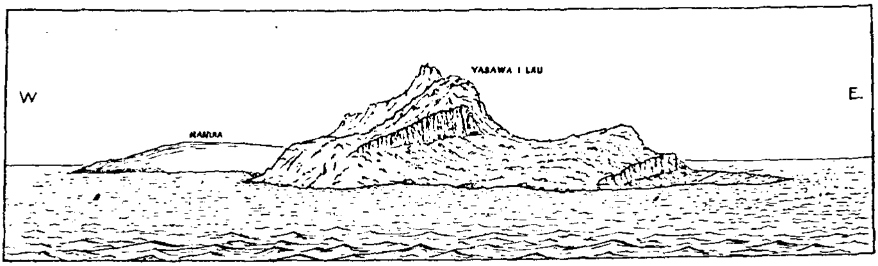

Figure 6. Yasawa-i-lau as seen from the Southwest.

The southern end of Yasawa-i-lau is composed of a sandy limestone similar to that composing the northern end of Nathula. Lenses of andesitic waste are interbedded with a glomeratic limestone. These beds are overlain by a more massive, coralliferous limestone, faulted down against them (Figure 7). The nature of the andesitic material interbedded with the limestone leads to the conclusion that volcanic activity was going on at the time the limestone was deposited.

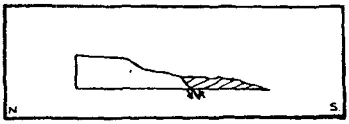

Figure 7. Fault at Southern End of Yasawa-i-lau.

Nanuia, a small island just north of Yasawa-i-lau, is connected with the latter by sand-bars which are exposed at low tide. Various under-cut islets of limestone dot the lagoon between the islands and occur also along the south side of Nanuia. Nanuia is a volcanic island made up of interbedded agglomerates and basalt flows. No contact between the limestone and the basalt could be found, though the limestone of the islets was seen within twenty feet of the volcanic rock. However, inasmuch as islands of volcanic ash, deposited under subaerial conditions, are found very close to Yasawa-i-lau with their bedding dipping towards the limestone cliffs, and since the outcrop of limestone at the northern end of Nathula is intruded by an andesitic dike, it was inferred that the volcanic rocks were erupted after the uplift and dissection of the limestone.

It is difficult to correlate the history of the Yasawa group with that of Viti Levu. In discussing the origin of the great barrier reef, it was stated that the lagoon was probably an old feature and had experienced a number of uplifts and depressions. The spine-like mass of limestone in Yasawa-i-lau is but a remnant of a formation once much more extensive. The destruction of so much elevated limestone can only mean that prolonged erosion has affected the area now occupied by the broad lagoon.

There is no reason to suppose that the Yasawa limestones are older than those of the Lau group, which will be described later. The limestones of Lau were elevated during, or soon after, the close of the Pleistocene period. The topography of the islands of the Yasawa group is much younger than that of the coastal hills of Viti Levu across the lagoon. The andesites forming the latter hills are assumed to be contemporaneous with the andesites underlying the sediments of the coastal plain.

These observations suggest that the andesites, extruded after the uplift and folding of the interior sediments of Viti Levu, were eroded, submerged, and overlain by coralliferous limestones and marls throughout the lagoon area; that during the Pleistocene these limestones were warped upward; and that they were then eroded and covered by ash and agglomerate during a more recent (Late Pleistocene or early Recent) period of vulcanism and have since been partly submerged, as shown by the embayed coast lines of the Yasawa Islands.

Outline of the Geological History of Western Viti Levu.

It should be understood that the paleontological evidence from the South Sea islands is so incomplete that the dates assigned to the various events are only approximations. The history, set down in order, is as follows: —

1) An old land of slates and red sandstones was intruded by a batholithic mass which solidified as gabbro, diorite, and granite.

2) The mountain block then formed was deeply eroded and the igneous rocks exposed.

3) Over the eroded surface andesitic flows were poured out.

4) The surface of these flows was deeply eroded and submerged.

5) A coralliferous conglomerate was laid down on the submerged

volcanic rock and, during a period of oscillatory movements, several hundred feet of marls and claystones with occasional thin seams of coal were deposited.

6) This period was followed by one of more decided submergence, during which approximately 150 feet of coralliferous[1] (?) limestone was laid down.

7) The limestones and older rocks were then uplifted, folded, faulted, and eroded.

8) A period of volcanic activity followed, during which andesitic flows and ash buried the eroded sediments.

9) A period of erosion followed.

10) The eroded hills of andesite were submerged along the edge of the island and a series of coastal sediments was deposited.

11) The island was then differentially uplifted and eroded.

12) Post-Glacial outbursts of volcanic activity built up the islands of the Yasawa group and injected dikes into the coastal areas of southwestern Viti Levu.

13) Recent differential movements have uplifted the coasts of Viti Levu and at the same time depressed the Yasawa islands.

EASTERN VITI LEVU.

Having outlined the history of western Viti Levu, the eastern part will now be described and its history compared with that of the western side.

The south-central coast of Viti Levu, between the Singatoka and Navua rivers, is formed of maturely dissected andesites. Sediments of the uplifted coastal plain, usually marls, surround the volcanic hills as far east as Serua Bay, along a coastal strip 25 miles in length. The sketch (Figure 8) shows the uplifted marls near Tangani, where they overlie ash and agglomerate beds and dip 12° to 15° S. E.

The accompanying map (Figure 9) illustrates the topography of the Navua delta plain. This plain is some 10 miles long and 6 miles wide. It is dotted here and there with hills of andesitic rocks. Many of them are so low and so deeply lateritized that they have been leveled by the sugar planters.

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[1] The writer found no corals in these limestones except in the basal beds underlying the marls. Workers in the Lands Department report corals in place, however, near the head waters of the Navua river, in limestones belonging to this series.

Along the east side of the river near its mouth, mangrove swamps once covered an area of dead coral reef for a mile inland. The dead reef does not rise above the present low-tide level. A considerable period of coastal stability, permitting the river-muds to be built forward over the dead reef for such a distance, is here indicated.

At a point a few miles west of the mouth of the river there are traces of an uplifted sea beach (Holmes, Government Surveyor). Other evidences of recent uplift are seen in the bench levels along the banks of the Navua, 8 or 10 miles from its mouth. The torrential streams, entering the river, flow across small delta flats before they reach the main stream. Eight miles up the river the uplift is estimated to be from 6 to 8 feet. It would appear that the Navua district either stood still or was downwarped during the period in which the coastal plain was uplifted to the west. More recently a slight uplift of the river's delta has taken place.

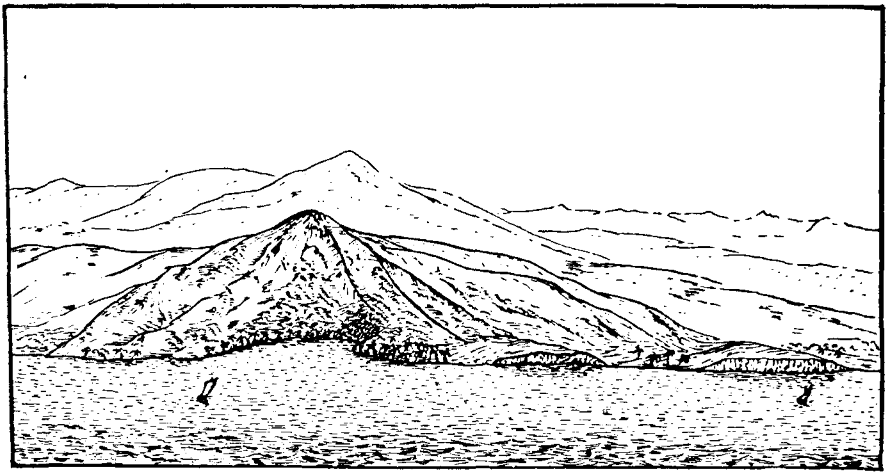


FIGURE 8. View of the Southern Coast of Viti Levu, near Tangani.

The Navua river, like the Singatoka, drains an area in part composed of granites and diorites; hence a considerable amount of coarser material is mixed with the fine clay of the river deposits. In extensive gravel flats, 10 or 12 miles from the river's mouth, boulders of

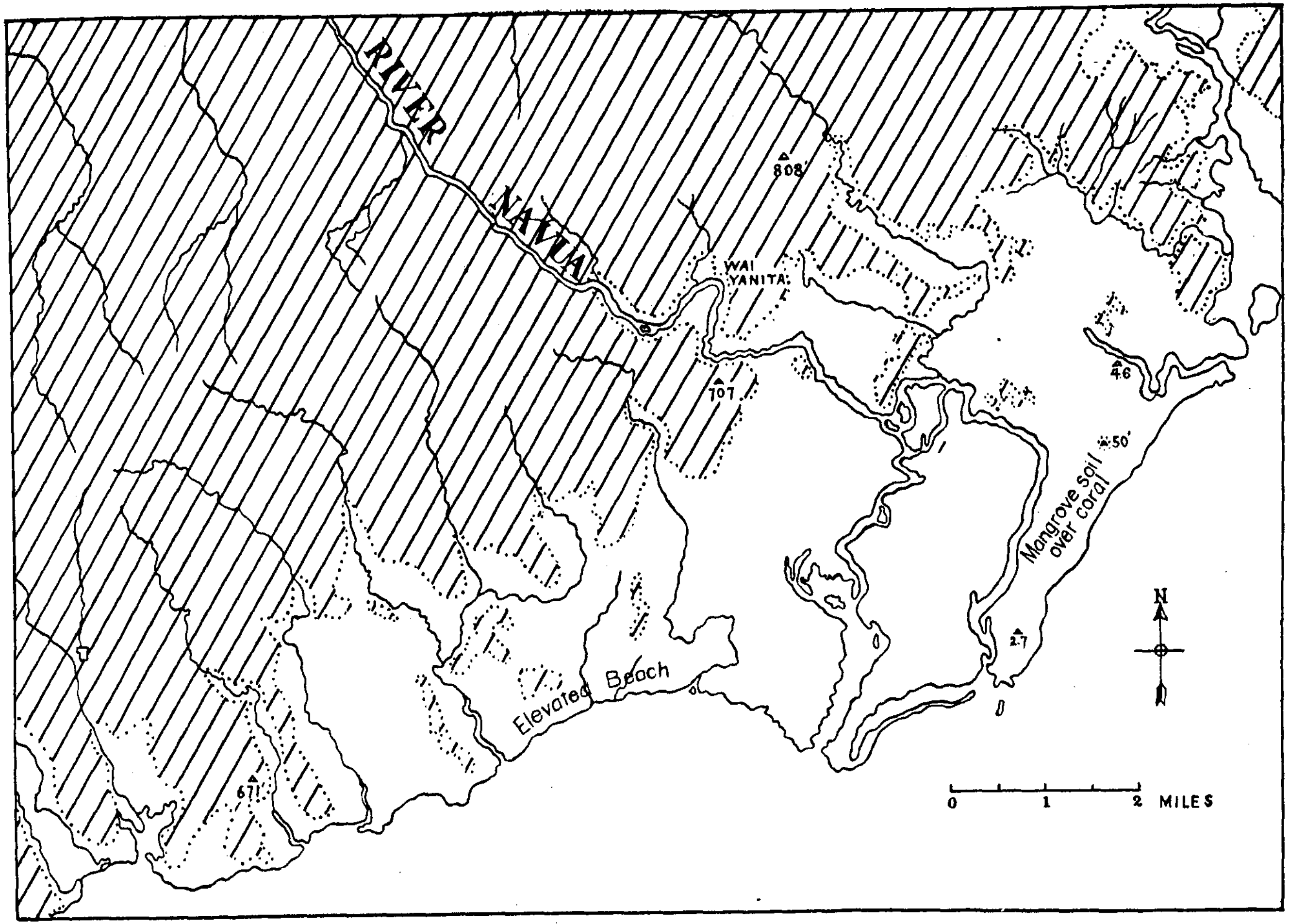

RIVER NAVUA
808'
WAI YANITA
707'
4.6'
50'
Mangrove Soil over coral
2.7'
Elevated Beach
671'
N
0 1 2 MILES

FIGURE 9. Sketch Map of the Navua Delta-plain. White — delta-plain. Lined — volcanic rocks.

diorite associated with sandstone were found. These rocks must be in place not far inland, but lack of time forbade a search for outcrops.

Volcanic rocks, carved into mature hills, form the shore-line for 4 or 5 miles east of the Navua delta plain. An outlying island, Nangara, 10 to 15 feet in height, marks the beginning of the coastal-plain marls. The sediments of the uplifted coastal strip occur at intervals, as jutting points of land or off-shore islands, for 14 or 15 miles to the east, or until the large area of marls forming the eastern side of the island near Suva entirely shuts off the volcanic rocks from the coast.

The short coastal rivers, cutting across the narrow coastal plain, have incised deep, subsequent valleys between the marls and the volcanic rocks just at their contact. This erosion, followed by a slight, recent submergence, has produced a considerable number of off-shore islands. Both processes have rendered it difficult to locate the contact of the coastal sediments with the interior volcanic rocks.

From the island of Nangara eastward, the coastal sediments rise higher and higher on the slope of the volcanic hills until at Tholo-i-Suva, 10 miles from the southeastern side of the island, they are found at an elevation of 700 feet. Along the western part of this strip of land, they do not, however, form the entire coast-line, since a number of the rivers have cleared the marls away from their mouths. The bay-heads usually show outcrops of volcanic rocks, while the projecting points and many of the islands are composed of marl, often interbedded with lenses of coralliferous limestone.

In order to study the relation of the uplifted coastal sediments to the interior volcanic rocks, several trips were made up the small rivers, emptying into Suva Harbor at the extreme southeastern end of the island. All of these rivers cut both the uplifted marls and the volcanic rocks upstream.

At the mouth of the Visari, the westernmost of these small streams, the marls dip 20° N. E. and overlie a conglomerate composed of boulders of diorite and granite. That the conglomerate is older than the surrounding andesite is shown farther up the river, where it disappears beneath a series of andesitic flows. An old rhyolitic breccia is associated with the conglomerate in a way which could not be determined. It is probable that the conglomerate was eroded from the interior granites before the great submergence during which the marl and limestone of the folded series of central Viti Levu were deposited.

The lower course of the Visari is very quiet, but at the contact of the conglomerate and the andesitic flows, 5 or 6 miles from its mouth, huge blocks of the andesite, have tumbled into the stream bed, and falls and rapids abound.

The diorite-bearing conglomerate is not exposed in any of the stream beds east of the Visari. Cross-sections up the Wai-ni-kuta and the Lami, the next streams in order toward the east, show the marls resting immediately on andesitic agglomerates. Up the Tamavua, the most easterly and largest stream entering Suva Harbor, a number of lateritized, maturely eroded hills of andesite are surrounded by marls containing isolated boulders of the same andesites. Along one of the branches of the Tamavua, entering 3 miles from its mouth, an andesite-boulder conglomerate, with a slight amount of marl as a matrix, outcrops. No contacts were seen, but the low dip of the beds and the outcropping of andesitic agglomerates only a short distance farther inland suggest that the conglomerate was eroded from the interior andesitic hills.

Numerous lenticular beds of coralliferous limestone occur within the marls about Suva Harbor. One such bed, 20 feet in thickness, is well exposed in a quarry just west of the town of Suva, on the eastern side of Walu Bay. The contact of the marl with the limestone is transitional. Sandstones overlie the marl and are themselves overlain by conglomerates enclosing broken shells in a calcareous matrix; finally, reef-coral appears. It is thus seen that a bottom composed of coarser shore-detritus is favorable to coral growth.

The coral layers dip eastward at angles of 15° to 20°. These dips may not represent the original angle of deposition, since numerous faults have tilted the blocks of marl and limestone in many directions. Three successive faults have dropped the coral limestone of Walu Bay 45 to 50 feet. The downthrow is always to the northwest. The faulting has given rise to a considerable duplication of the beds and accounts for the irregularity of the limestone outcrop about Suva Harbor. Up the Tamavua river a basal shell-limestone is associated with a calcareous conglomerate which undoubtedly rests on maturely dissected andesitic rocks.

The dioritic rocks of the central core of Viti Levu were not found in place, but they occur in an ancient conglomerate. This conglomerate is overlain by andesite flows, probably of the same age as the andesitic materials overlying the folded and faulted marls and limestones of central Viti Levu. The andesitic flows and agglomerates have been maturely dissected and a series of conglomerates, marls, and interbedded coral limestones laid down about the volcanic terrane, as in the western part of the island. These coastal deposits were later uplifted.

The question remains as to why there is a fringing reef near the mouth of the Singatoka, while off Suva there is a wide and deep lagoon within a barrier reef. The writer believes that two special causes have produced this effect. First, the sediments brought down in abundance by the Rewa river are very fine. They float for a considerable distance out to sea before they are precipitated and are swept by prevailing currents to the westward, along the south shore of the island. The charts show that the reef is indeed fringing east of the river's mouth. The coral is able to grow only beyond the zone of maximum precipitation of the silt. The present barrier reef, therefore, is growing upward on the delta platform of the Rewa river just as the former, uplifted reefs developed in a previous cycle.

Second, the uplifted marls about Suva Harbor present an irregular coast line and an inland topography which cannot be explained by stream erosion. The direct evidence of block-faulting exposed in the Walu Bay quarry is suggestive that the uplift of the coastal marls was accompanied by downthrow and that the lagoon flat of Suva Harbor represents a depressed portion of the uplifted delta.

Comparison of Results with those of Previous Workers.

The history of Viti Levu, as presented above, is somewhat at variance with the older accounts of other geologists. Thus, Andrews describes an unconformity between an older and newer series of limestones at the mouth of the Singatoka river. The coastal plain series at this point appeared to be entirely conformable but, if the writer is correct and intermittent uplifts have characterized the elevatory movements of the coastal plain series, it would not be surprising to find a slight unconformity between an older series of tilted limestones and the very recently uplifted series of coralliferous limestones occurring west of the mouth of the Singatoka river.

A more serious discrepancy is found between the mapping of Woolnough and the descriptions of the present writer. Woolnough does not discriminate between the different marls of Fiji. He mentions the fact that near the mouth of the Rewa these beds are comparatively flat, while near the head-waters of the Navua and Rewa rivers they are considerably folded. This variance in structure, however, is not interpreted to mean a difference in age.

Further, it would appear from his text that Woolnough did not visit the Navua delta plain. He saw the flat country from the hills at the fork of the Navua and Wainikoro-iluva rivers and inferred that it was an elevated plain of marls similar to that near the mouth of the Rewa river. On the contrary, the Navua has incised a series of youthful valleys in a fairly level plateau of andesitic agglomerates. Near the coast, erosion carved the plateau into mature hills, which were later submerged, forming a delta plain about deeply lateritized hills of andesitic agglomerate.

The marl series at the mouth of the Rewa which Woolnough considers Miocene, because of fossils found in the Suva quarries, is believed, therefore, to be much less extensive than is indicated on his map.

In the limited portion of central Viti Levu which was seen, the folded series has a general strike of E. N. E. - S. S. W. as stated by Woolnough. This strike agrees more fully with the structure lines of Suess than with those of Dana or Gregory (Marshall, 1912, p. 3).

Jensen (1907, p. 49) has described an occurrence of chalcopyrite associated with andesite near Lautoka. It may be useful to state that where chalcopyrite was found by the writer it was associated with the older flows of andesite which flooded the eroded plutonic rocks. The folded series of Viti Levu lies above this andesite, which is much faulted and brecciated.

GEOLOGICAL HISTORY OF VANUA LEVU.

INTRODUCTION.

Because of limited time and unfavorable weather, the writer saw less of Vanua Levu than of Viti Levu. The western part of Vanua Levu was not visited, but it is known to be underlain by sandstones and other sediments, similar to those described in central Viti Levu (Guppy, 1903).

PHYSIOGRAPHY.

The outline of Vanua Levu is by no means as regular as that of Viti Levu. The eastern portion of the island is split by a long, narrow bay extending inland, to the southwest, for 50 miles. To the eastern peninsula, thus formed, are appended several minor peninsulas

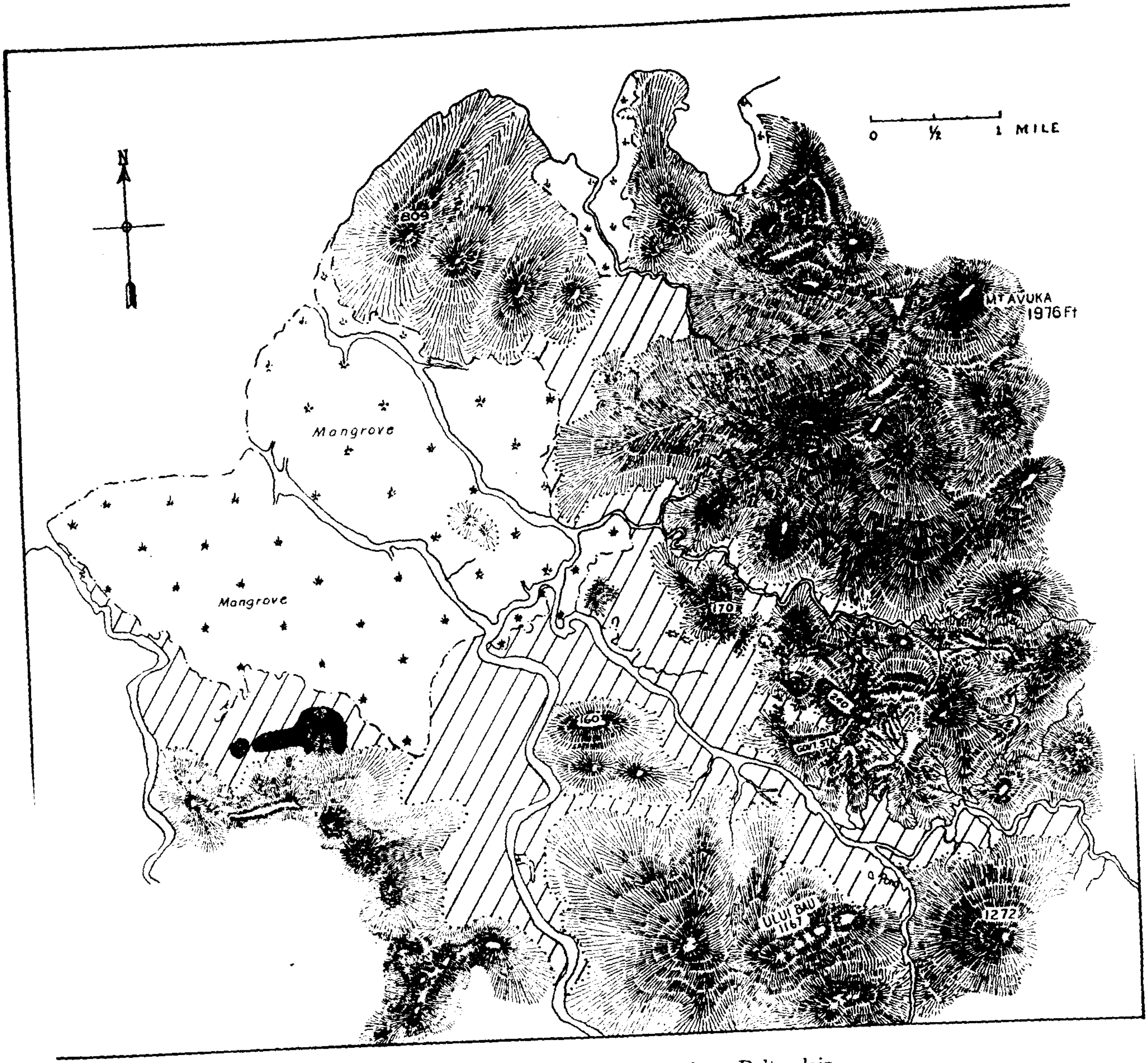

N
0
½
1 MILE
809
MT AVUKA
1976 Ft
Mangrove
Mangrove
170
160
240
GOVT STA
Pond
ULUI BAU
1167
1272

FIGURE 10. Sketch Map of the Lambasa Delta-plain.
Drawn by Wright after a Sketch by Le Roex.
Lined — delta sediments. Black — limestone.

which jut out to the eastward. A few miles off-shore, many small islands further complicate the coastal forms about Vanua Levu. The entire circumference of the main island is marked by pocket harbors and jutting headlands.

The rocks of the island are primarily andesitic ash and agglomerates, though a series of rhyolitic-ash deposits occurs along the northeastern coast. The rocks of the eastern side of the island, deposited subaerially, have never been submerged, and are maturely dissected.

The andesites of the central part of the island are submarine in origin. They once formed a wide, submarine platform of gentle slope, which was later elevated 3000 to 4000 feet and dissected into irregular hills forming a mature to late-mature topography.

LAMBASA DISTRICT.

The low, sugar-cane lands, formed by the delta flat of the Lambasa river, lie a little east of the center of the northern coast of Vanua Levu. The accompanying map (Figure 10) shows the topography of the area. Two tidal rivers, the Nghawa and the Lambasa, have deposited the silts of the delta which is continuous with flood plains far back among the hills. Several residual masses of volcanic rocks stand isolated within these plains, their bases covered with delta sediments (Figure 11).

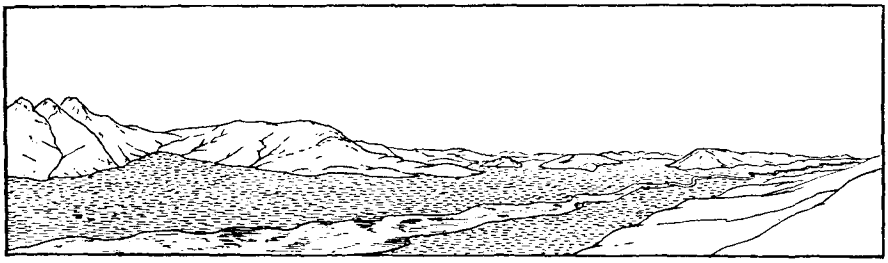


FIGURE 11. View of the Lambasa Delta-plain.
Drawn by Wright after a Photograph.

The region drained by the two rivers mentioned was once occupied by several andesitic volcanoes. The ash deposits which covered the cones were laid down beneath the sea. After later uplift the volcanoes were so deeply eroded that their central agglomerates are now exposed in abrupt cliffs, and the surrounding ash beds have been carved into hog-back ridges. Certain interbedded lava flows were eroded, to form fingering points extending seaward.

Following this period of erosion, the island subsided and coralliferous limestones were deposited about the spur-ends of the hills extending seaward. These deposits have been largely swept away by subsequent erosion. They are known to occur on the northern side of Vanua Levu only at one locality, three miles west of the Lambasa river near its mouth. Here, as shown in the sketch (Figure 12), coralliferous limestones lie in a valley cut in the andesite. The limestone is quite different in appearance from that found elsewhere in the group. It has a paste of light, slate-colored marl. On weathering, the silver-gray of the marl changes to cream-white. A shell-limestone, with occasional small pebbles of andesite, underlies the deposit, while a yellow sandy marl caps it in places.

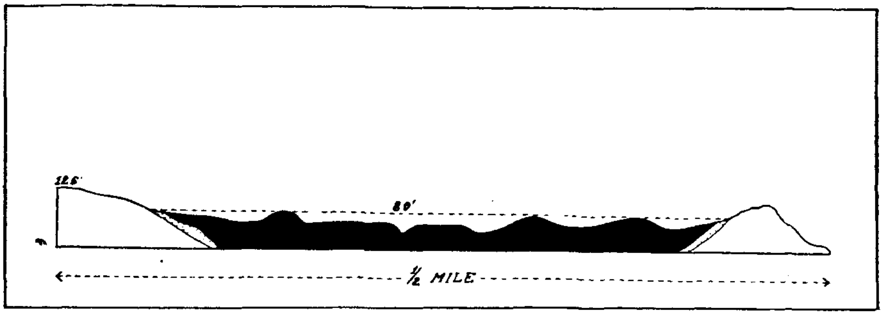


FIGURE 12. Cross-section of an Elevated Coral-reef near Lambasa, Vanua Levu.
White — volcanic rock. Dotted — basal conglomerate. Black — elevated coral reef.

During the period of crustal stability following the subsidence, continued dissection of the andesite produced a series of wide valley floors dotted with residual hills extending far inland. The edge of the central plateau of agglomerates and fossiliferous tuffs retreated farther and farther towards the interior and peaks were carved by erosion from the disappearing mass. The valley peneplain thus formed is now found at an elevation of 125 to 150 feet above sea-level, and may be seen in crossing Vanua Levu from Lambasa southward to Savu Savu Bay on the southern coast of the island. The first part of this journey leads along the flats of the Lambasa river. Then an ascent of 125 to 150 feet brings one to a wide plain stretching inland for 15 to 20 miles. The rocks underlying this plain are largely vesicular, andesitic lava, seamed with chalcedonic veins and containing amygdules of chalcedony and quartz. Calcareous ash-beds also occur. Near the top of the ridge forming the central divide of the island, fossiliferous tuffs are formed at elevations from 2500 to 2700 feet.

The evidence gathered at the coralliferous-limestone exposure led the writer to believe that, following the formation of the valley peneplain, there was an uplift of 80 to 90 feet; then a short period of stability during which a shore platform was cut in the soft limestones. Later, another uplift of 40 to 50 feet allowed valleys to be carved in the shore platform thus formed. Still more recently a rise of sea-level has allowed 10 to 15 feet of volcanic silts to accumulate in these valleys.

A visit to the divide east of the Lambasa plain and southeast of Mt. Avuka (see sketch map, Figure 10) showed that other stages could be recognized in the history of the island. The road winds gradually up from the river flats over a series of low lateritized hills, and then follows the course of a small creek (Na Suvu) which has carved in the laterite a gorge-like valley, 20 to 30 feet deep.

At an elevation of 350 feet, the lateritized materials have been washed away and occasionally the true nature of the rocks may be seen. They are glassy lavas, unconformably overlying maturely dissected gabbro. Ascending still further to the divide at an elevation of 750 feet, the gabbros are lost for a time but appear again along the axis of the ridge. They outcrop for 200 yards along the road as it passes over the divide and, south of the road, rise in a dome 1100 feet high.

On the eastern slope of the divide, pitchstone pebbles are associated with the glassy flow lava which mantles the gabbro surface. To the north, Mount Avuka, 1976 feet in height, is formed of andesitic ash and agglomerate which overlie the glassy flows conformably.

An outline of the history of north-central Vanua Levu is, therefore, somewhat as follows: —

(1) An old land of plutonic rocks was maturely dissected and submerged.

(2) During the great submergence a thick series of volcanic rocks was laid down; first acid flows and later andesitic ash and agglomerates.

(3) A period of uplift followed, during which the submarine tuffs and agglomerates were elevated over 2400 feet (Guppy, 1903, p. 154).

(4) The succeeding period of erosion carved the uplifted volcanic mass into a mature topography.

(5) A period of submergence followed, during which coralliferous limestones were deposited about the spur ends of the mature hills along the coast.

(6) A period of stability allowed wide valleys to be opened in the interior.

(7) A later uplift of 80 to 90 feet was followed by a short period of stability during which a shore platform was wave-cut on the soft limestones.

(8) Renewed uplift of 40 to 50 feet allowed valleys to be carved in the shore platform of (7).

(9) A recent rise of the sea-level has filled the valleys of (8) with volcanic silts.

NORTHERN COAST OF VANUA LEVU, EAST OF LAMBASA.

A rapid trip of 30 miles was made by train, along the northeastern coast of Vanua Levu, east of Lambasa. The rocks exposed are rhyolitic ash and agglomerate. These have been maturely dissected and wide valleys, extending far inland, are found at intervals of 5 to 7 miles along the shore. The coast is very irregular and typically embayed.

The history of this coast appears to be the same as that near Lambasa. During the period in which inland valleys were formed, wave erosion cut into the rhyolitic deposits of many of the volcanic cones along the coast and formed sea-cliffs 300 to 400 feet in height. The friable nature of the rhyolitic ash-beds allowed rapid cliffing. As the cliffs retreated, certain craters seem to have been breached, so that the ocean water entered their floors. The remnants of the crater walls, forming islands and headlands about the bays, show quaquaversal dips.

The floors of the wide valleys of this region stand at a less elevation above the sea than those near Lambasa. Either the uplift, following erosion, was not as great towards the east or, it may be, the depression following uplift was greater. The ocean is now attacking the shore again and carving from the rhyolitic ash a series of undercut cliffs, 20 to 30 feet in height.

MBUTHA BAY DISTRICT.

The Mbutha Bay District constitutes the extreme eastern side of Vanua Levu. The district may be divided into two parts. Between Mbutha Bay and the long, narrow depression forming Natewa Bay, a continuous range of uniform structure and vegetation stretches in a northeast-southwest direction for 50 miles or more. This range has been called, by Guppy, the Natewa peninsula. The island of Kioa, lying a few miles to the east of the mainland and forming part of the enclosing land about Mbutha Bay, has a similar structure, and with a promontory on the southwest, forms a spur of the Natewa Peninsula.

The land at the southeastern end of Vanua Levu, Guppy has called the Waikava Peninsula. The eastern half of this peninsula constitutes the second part of the Mbutha Bay District.

The first-mentioned sub-division of the district, including Natewa Peninsula, is underlain by non-fossiliferous ash-beds, agglomerates, and lava flows of sub-aerial origin. On them, erosion has developed a sub-mature topography. The divide between Mbutha Bay and Natewa Bay is very close to Natewa Bay, so that its northwestern slopes are much steeper than its southeastern slopes. To the east of the divide, along the axis of the range, a number of high-standing basins, a mile to a mile and a half in width, are enclosed on nearly all sides by precipitous walls. The rocks about the basins show quaquaversal dips and the small streams draining the basins issue through narrow openings in the enclosing walls. The basins are, therefore, considered to be old craters.

The river at the head of Mbutha Bay has cut its valley across a series of ash-beds. Its lower course is embayed by a recent submergence, further evidences of which are seen about the shores of Mbutha Bay. Delta-filled valleys abound. The shore-lines of Rambi and Kioa demonstrate the embayment. The accompanying sketch map (Figure 13) shows the coastal outline of the bay.

The killing of coral patches by an advancing delta was observed about the shores. Near the head of the bay, (see sketch map), the coral patches are dead and submerged about one fathom. As the open waters to the north are approached the coral thrives more and more, attaining vigorous growth where the currents sweep in between Rambi and Kioa.

Just east of the small promontory jutting out from the Waikava

Peninsula towards the island of Kioa, the land slopes gradually downward toward a depression which crosses the whole width of the main peninsula. Southeast of the gap, the hills are eroded to late maturity and are deeply lateritized. Their red slopes, overgrown with reeds, are in distinct contrast to the well-watered slopes clad with verdure about Mbutha Bay. This area forms the second part of the district.

The rocks of this district cannot be exactly correlated with those about Lambasa. The andesites of the Natewa peninsula are less dissected than the Lambasa andesites and the interbedded ash gives no evidence of having been laid down beneath the sea. These volcanic rocks are, therefore, probably not of the same age. It may be possible that the more dissected andesites of Waikava Peninsula corresponds to the Lambasa volcanics but most of the rocks of the peninsula are believed to have been erupted since the main uplift of the island.

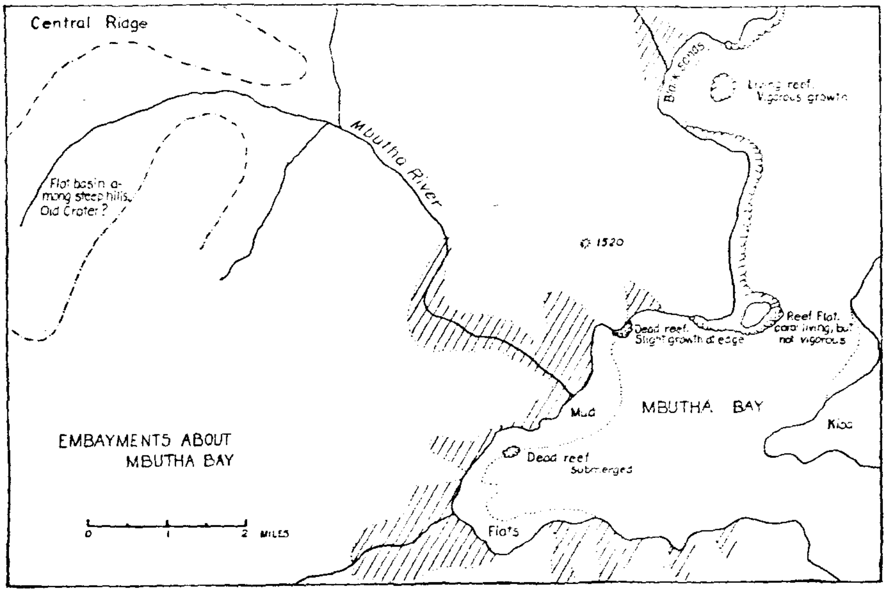

Central Ridge
Mbutha River
Black sands
Living reef. Vigorous growth
Flat basin among steep hills. Old Crater?
1520
Dead reef. Slight growth at edge
Reef Flat. coral living, but not vigorous
Mud
MBUTHA BAY
Kioa
Dead reef Submerged
Flats
EMBAYMENTS ABOUT MBUTHA BAY
0 1 2 MILES

FIGURE 13. Embayments about Mbutha Bay, Vanua Levu.

SOUTHERN COAST OF VANUA LEVU.

Only two sections of the southern coast of Vanua Levu were seen by the writer. Each of these was 15 or 20 miles in length and contained areas of uplifted limestone. The first section runs along the southern side of the Waikava peninsula at the southeastern end of the island and extends westward for 5 or 6 miles beyond Fawn Harbor. The second section was made in the vicinity of Savu Savu Bay.

Crossing the Waikava peninsula from the river flat at the head of Mbutha Bay, the land rises to an elevation of 1200 feet within the space of a mile. Near the divide, the peninsula, composed of andesitic ash and agglomerate, presents a sub-mature topography.

As one approaches Fawn Harbor from the east, the highlands of agglomerate retreat gradually from the coast, and a wave-cut bench appears at an elevation of 75 to 80 feet. The agglomerates below the bench level are overlain by fine ash deposits containing some sea shells and a calcareous matrix. The ash unconformably mantles the domes formed by the late-mature dissection of the agglomerates.

A series of islets, composed of ash and agglomerate, cross the mouth of Fawn Harbor. The bay-heads at either side are underlain by loose, fine, volcanic marls, which have been benched by the sea at its present level; the resulting platform slopes seaward at a very low angle (3° to 4°). This platform may be traced for a half a mile out to sea. Just west of the western head-land, the loose yellow and red fossiliferous marls are carved into hoodoo stacks standing 15 to 20 feet above sea-level. For a few miles west of Fawn Harbor, the elevated wave-cut bench extends a mile or two inland. Five miles west of the harbor, near the little village of Vunilangi, the seaward border of the bench has a fringe of raised coralliferous limestone.

The plan and cross-section (Figure 14) show the prevailing conditions. Back of an outer rim of raised coral heads, 10 to 15 feet in height and 100 to 200 yards wide, is a wide flat which was formerly covered by 2 to 3 feet of water. Artificial drainage has made the flat dry and arable. The drain-cuttings show that the plain is underlain by a limestone, composed of shell and coral waste with an occasional coral head in place. A hill 60 to 70 feet high rises in the midst of the flat and represents an isolated dome of andesite unconformably overlain by coralliferous limestone to its summit.

The relations at this place point to very recent uplift. At the time when the sea was cutting, in the andesite, a bench at an elevation of 75 to 80 feet about present sea-level, a reef was forming out to sea on the maturely eroded topography of the andesite. The succeeding uplift has been so recent that none of these features is yet destroyed.

The observations made in the second traverse on the southern coast may now be noted. Savu Savu Bay is a wide, enclosed sheet of water, reaching 8 to 10 miles towards the center of Vanua Levu. The sub-mature hills overlooking the bay are composed of rocks similar to those found about Lambasa. The lower slopes display andesitic

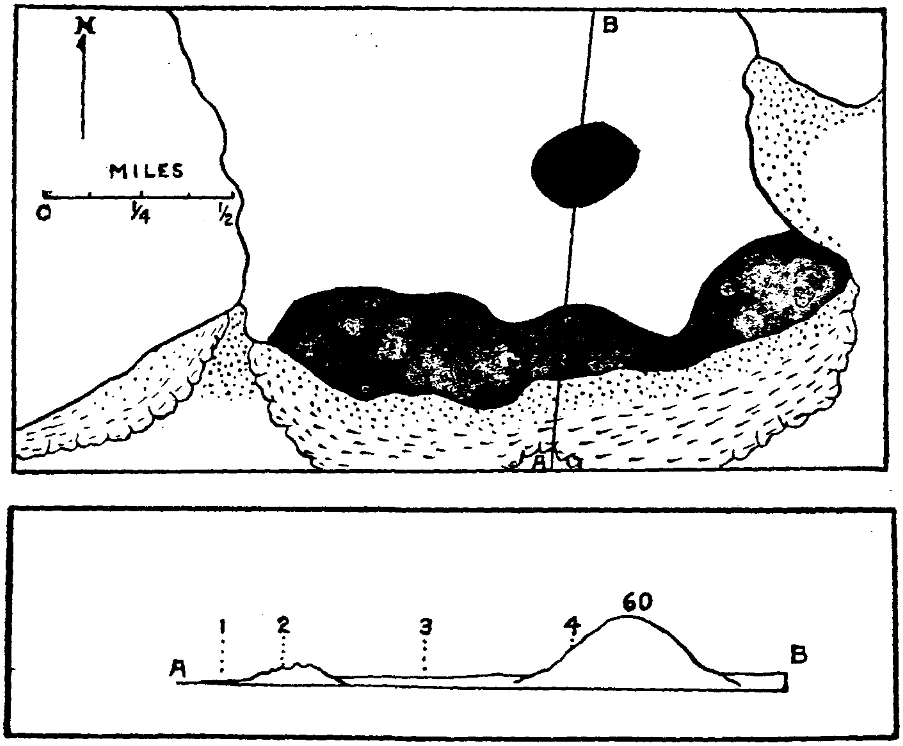


FIGURE 14. Sketch Map and Cross-section of an Elevated Coral-reef near Vunilangi, Vanua Levu.

White — coralliferous lagoon sediments. Black — elevated reef. 1 — Sandy beach. 2 — Elevated barrier reef. 3 — Elevated lagoon flat. 4 — Coral-covered knoll.

agglomerates and flows. Near the summits of the residual hills, carved from the high-level plateau of the interior, shell-bearing tuffs, interbedded with agglomerates, were found.

There is but one large river flowing into Savu Savu Bay. This river flows from the north and enters the north-central portion of the bay. A few small streams drain the seaward slopes of the ridges, but by far the greater part of the run-off from the back country is carried by a series of subsequent streams into the through-going river. The mouth of the river has flood-plain deposits 4 or 5 miles inland. The tide rises and falls in a tidal estuary, immediately above which the flood-plain deposits cease and the river becomes a narrow torrential stream with a boulder stream bed. There has been a recent submergence of the river's mouth.

Guppy, (1903, p. 182) reports gabbros on the divide between Savu Savu and Natewa Bays. These rocks were not seen by the writer. Their presence indicates at least some similarity in the history of the southern part of the island to that about Lambasa. In both districts, hot springs with temperatures near the boiling point suggests that the areas are now in the expiring stages of volcanic activity.

The most interesting area in the Savu Savu Bay district lies along the sea-coast, east of the eastern bayhead. The present fringing reef seaward from this bayhead is nearly a mile in width. At the western end of the reef there is a small island of elevated coralliferous limestone of lagoon origin. This limestone is lacking for two or three miles eastward from the headland, and a sandy plain extends a quarter of a mile inland to the late-mature, andesitic hills forming the center of the peninsula. Two and a half miles east of the headland and about 200 yards inland, a rise of land called Ndela-ni-koro, is formed of coralliferous limestone overlying a late mature topography of andesite, (Figure 15). The hill is between 110 and 120 feet high. From this point to the village of Nandi, 5 miles east of the bayhead, the tips of the promontories are covered with elevated coralliferous limestone.

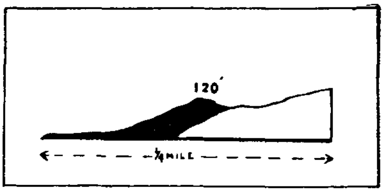


FIGURE 15. Ndela-ni-koro, near Nandi, Vanua Levu.
White — volcanic rock. Black — elevated coral reef.

At Nandi, the eroded andesites were once depressed below the sea, covered unconformably with lava flows which were conformably over-

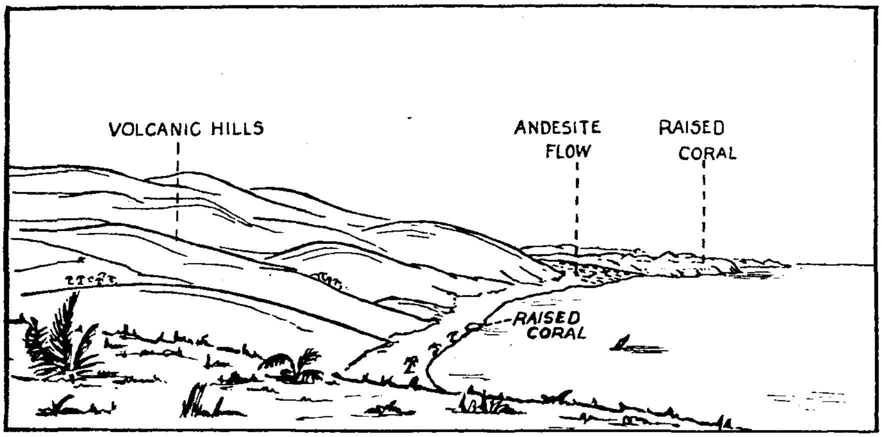
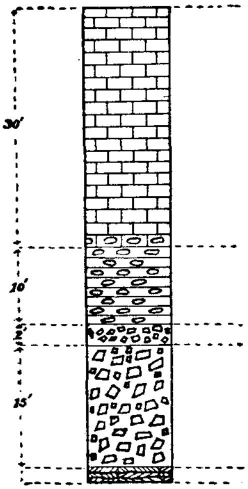

VOLCANIC HILLS
ANDESITE FLOW
RAISED CORAL
RAISED CORAL

Figure 16. View of an Elevated Coral-reef near Nandi, Vanua Levu.



Massive coral heads and rubble-waste in proportion of one to one. Andesitic boulders 1 foot in diameter at base.

Calcareous conglomerate containing coral and volcanic pebbles.

Calcareous agglomerate.

Coarse agglomerate with ash matrix.

Andesitic flow.

Figure 17. Columnar Section of an Elevated Coral-reef near Nandi, Vanua Levu.

lain by limestone, and later uplifted. The river, draining the interior, has been extended across the elevated reef limestones. On either side of the bay at its mouth continuous areas of uplifted limestone stretch for half a mile along the coast.

The sketch (Figure 16) illustrates the type of topography near Nandi. The limestone is nearly 40 feet in thickness and dips 3° to 4° S. E. The rocks underlying the limestone are given in the columnar section (Figure 17).

The section indicates that here andesite was erupted during the deposition of the limestone and the other conformable sediments. Farther east no andesite of this relatively late date has been discovered, all the andesites observed being unconformable below the limestone.

TAVIUNI.

The island of Taviuni with its reefs is shown in the sketch map, (Figure 18). Three periods are definitely indicated in the history of the island. They are most easily recognized in its northwestern part, where maturely eroded andesites are surmounted by a number of recent cones, from which basaltic lavas have spread north and east over the adjacent country.

Along the central and northern borders of the island there is an irregular bench, probably cut by wave-action, on the mature and deeply lateritized hills. The bench stands at an elevation of 75 to 150 feet and from it rather abrupt slopes descend to sea level.

Near the west-central coast of the island, recent basalt flows lie within a valley carved below this bench level. The order of events which gave rise to the valley incised in the bench is not clear. The maturely eroded andesites may have been submerged, a bench cut, and later elevated; or the bench may have been cut during a pause in the general uplift of the island.

A continuous northeast-southwest ridge, bearing some of the highest peaks of Fiji, runs through the middle of Taviuni. Near the very center of the island is an old crater whose flat floor is occupied by a shrinking lake. The floor is a mile wide and two or three miles long. It is dotted with two or more small hills which rise from the lake. The crater is rimmed with precipitous cliffs, 200 to 300 feet in height. One of the streams flowing towards the eastern side of the island is said by settlers to breach these cliffs.

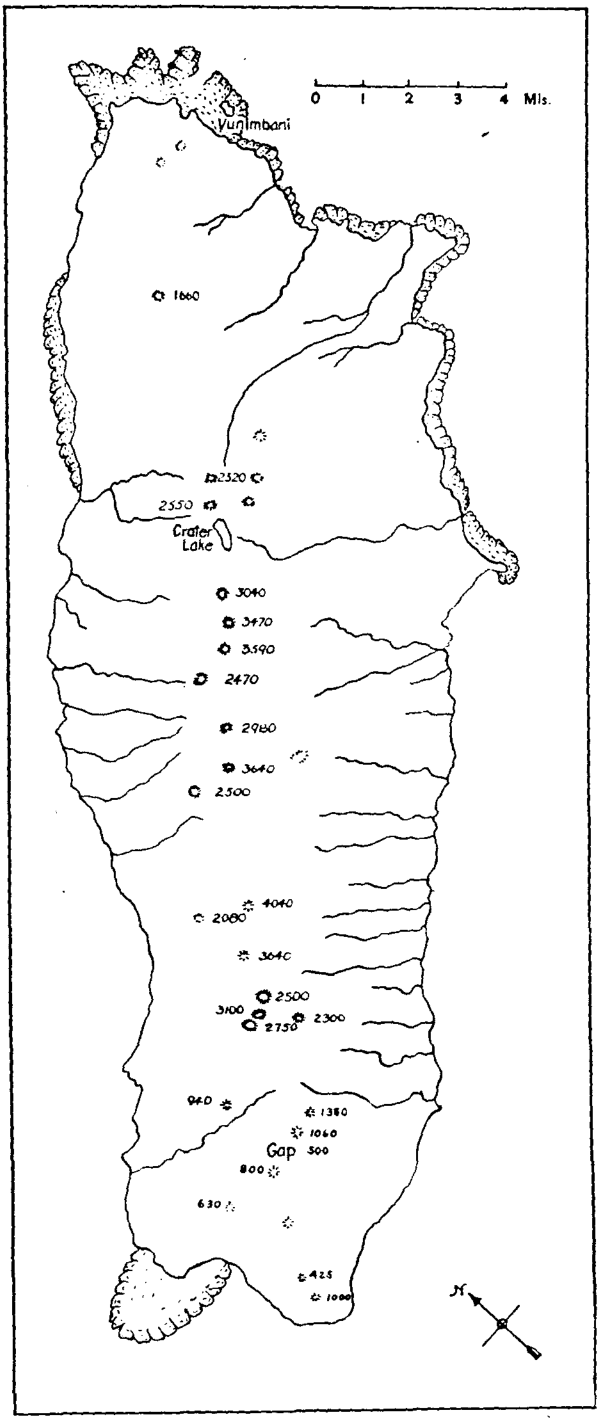

0 1 2 3 4 Mls.
Vunimbani
1660
2520
2550
Crater Lake
3040
3470
3590
2470
2980
3640
2500
4040
2080
3640
2500
3100
2750
2300
940
1380
1060
Gap
500
800
630
425
1000
N

FIGURE 18. Sketch Map of Taviuni.

From the central ridge steep slopes, of 30 to 35 degrees, descend to the sea. The slopes of the central and southern parts of the island are largely underlain by basaltic flows and agglomerate. It is difficult to reconcile the steepness of the slopes with the general fluidity of basaltic lava, if basalts constitute the whole depth of the ridge down to the sea-level. The problem becomes less serious if it be assumed that the basalts actually form a relatively small part of the mass; that is, a veneer on the older andesites exposed at the northern end of the island. In certain places, the basalts present an abrupt change of level as they approach the coast, as though they had flowed out over the bench on the older andesites above described.

At the southern end of the island, a series of seven or eight cones, 700 to 800 feet in height, rise above a nearly flat basaltic plain. These cones are arranged along a north-south line, approximately parallel to the main ridge of the island.

Two different explanations of the isolated reef at the southern end of Taviuni are conceivable. It may represent part of an old reef which was not entirely covered by the recent basalt flows. If so, the depths of 50 to 75 fathoms close to the shore represent the original descent from the edge of the reef into the ocean abyss. On the other hand, the existing reef may be due to the colonization of the flat surface of a recent lava flow extending beneath the sea. The latter hypothesis leaves unexplained the considerable depths close to the land. Block-faulting may account for the sharp descent.

It is easy to postulate faulting in order to explain certain features about Taviuni but difficult to prove it. For example, Goat Island, lying two or three miles off the west coast, is composed of ash-beds which are gently folded and dip towards the basaltic slopes of Taviuni. The present dip would seem to indicate that the source of this ash lay to the west. A deep channel, however, separates the island from Vanua Levu in that direction. It is not impossible that faulting has formed the strait and destroyed the center of eruption from which the ash was ejected. Yet the beds may simply be an erosion remnant cut off from Taviuni.

Again the small island, Vunimbani (200 feet high), off the northeast coast of Taviuni is capped by 15 to 20 feet of water-laid ash, dipping 5° N. E., and overlying flows and agglomerates. The island is connected with Taviuni by a flat exposed at low tide. The coast of the larger island at this point is composed of deeply lateritized basalts whose topography is quite unlike that of Vunimbani.

The accompanying sketch (Figure 19) was made from the northwestern side of Taviuni, looking southward along the coast towards the outlying island of Ngamia. It illustrates the low topography of recent basalt flows which cover the older hills in northeastern Taviuni. It also shows the mature topography of Ngamia and its embayed shore-line. The irregular outline of this island is in distinct contrast to the rather regular outline of Taviuni. If the latter island, like Ngamia, has been submerged, it should also be embayed along its northern shore. The lack of such embayment indicates that either still-stand or uplift has characterized the recent history of the island.

The continuous series of vents along the northeast-southwest central ridge of Taviuni is doubtless located on a fracture-line. Block-faulting along parallel lines possibly accounts for the depths of 75 to 150 fathoms along the eastern and western sides of the island, close to the shore. Yet no evidence favoring this hypothesis is at hand, and the present slope of the modern basalt flows, if continued beneath the sea, would furnish almost as steep a descent to deep water.

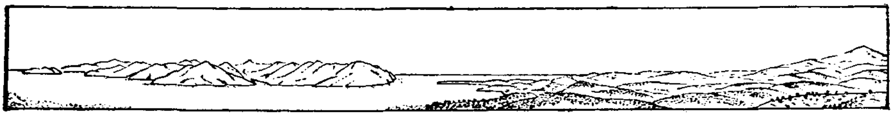


FIGURE 19. View of Ngamia and Northwestern Taviuni from Nangasau.

Besides an intermediate period of uplift, Taviuni, like the district about Mbutha Bay, shows two other distinct periods in its development. The older is that of mature or late-mature erosion and lateritization of andesitic rocks; the younger, that in which more basic rocks were extruded.

The points of greatest importance to be noted in the following table are: —

1) Old cores of plutonic rocks form the centers of both Vanua Levu and Viti Levu.

2) Most of the districts show one period of great subsidence.

3) The submarine volcanic rocks of central Vanua Levu are lacking in eastern Vanua Levu and Taviuni.

4) One period of rhyolitic activity, two periods of andesitic activity, and a later period of basaltic activity are manifested in these islands.

The following table presents a summary of the more important periods in the different districts just described. The periods which are considered to be essentially contemporaneous are indicated by the same numbers.

I *Singatoka River-Viti Levu.*	II *Yasawa Group.*	III *Lambasa-Vanua Levu.*	IV *Mbutha Bay-Vanua Levu.*	V *Savu Savu Bay-Vanua Levu.*	VI *Taviuni.*
1) Plutonic rocks, intruded into slates and sandstones, eroded to late maturity.		Plutonic rocks eroded to late maturity.		Plutonic rocks eroded to late-maturity.	
2) These rocks flooded by lavas of the first period of andesitic eruptivity.		These rocks flooded by rhyolitic and andesitic lava.			
3) Erosion of the andesites.					
4) Great subsidence; deposition of marls, sandstones and limestones of folded series.			Eruption of lava and ash of first andesitic period.		
5) Uplift and erosion of sediments formed in period (4).					
6) Explosive material of second period of andesitic activity covers the sediments.	Eruption of lava and ash of second andesitic period.	Great subsidence; deposition of marine tuffs and agglomerate of second andesitic period.	Eruption of lava and ash of second andesitic period.	Great subsidence; deposition of marine tuffs and agglomerates of second andesitic period.	Eruption of lavas and ash of second andesitic period
7) Mature erosion of volcanoes of second andesitic period.	Erosion of andesites.	Uplift and erosion of the submarine volcanic rocks.	Submature erosion of lavas of second andesitic period.	Uplift and erosion of the pyroclastics.	Late-mature erosion of the andesites.
8) Subsidence; deposition of 100 to 200 feet of coastal marls and coralliferous limestones unconformably on andesites of second volcanic period.	Subsidence; deposition of 300 to 400 feet of limestone.	Subsidence; deposition of 50 to 100 feet of coastal sediments unconformably on maturely eroded andesites.		Subsidence; deposition of coastal sediments.	
9) Uplift and erosion of coastal sediments.	Uplift and erosion of the limestones.	Uplift and erosion of coastal sediments.		Uplift and slight dissection of coastal sediments.	Uplift and cutting of marine bench in the andesites.
10) Intrusion of basalts into coastal sediments.	a. Explosive materials of basaltic period cover sediments. b. Submature erosion of volcanoes of basaltic period.			a. Eruption of lavas of basaltic period. b. Erosion of basalts.	a. Extrusion of basalts. b. Sub-mature erosion of basalts.
11) Submergence (?).	Submergence.	Submergence.	Submergence.	Submergence.	Submergence (?)

GEOLOGICAL HISTORY OF THE SMALLER ISLANDS, ESPECIALLY THE LAU GROUP.

INTRODUCTION.

During an extended exploration of the Lau Group which lies to the east of the larger island of Fiji, the writer reached the following conclusions: —

1) The Lau islands are underlain by volcanics, formed during the second period of andesitic eruptivity, then maturely eroded, and finally submerged.

2) During long submergence, coralliferous limestones were laid down unconformably on these volcanic rocks.

3) A later uplift elevated the coralliferous limestones above sea-level.

4) During a later basaltic period of volcanic eruptivity, olivine andesites or basalts intruded the elevated limestones.

5) With succeeding erosion a large amount of the elevated limestones disappeared, largely owing to atmospheric solution.

6) Most of the islands show a recent submergence.

According as the various islands have passed through all, or only a part, of these stages, the Lau islands may be classified as follows: —

I. Islands depressed and covered with limestone and later uplifted and intruded or covered by volcanic rocks of the second period.
    A. Islands depressed so deeply that the tops of the andesitic hills of the first period were covered by limestone.
        1) Islands with limestone partly or wholly eroded from the summits of the andesite.
            Vanua Mbalavu
            Susui
        2) Islands with volcanic rocks of first period still covered with limestone.
            Kambara
    B. Islands whose tops were never covered by limestone.
            Kandavu
II. Islands depressed and covered with limestone and later uplifted but not affected by the second period of volcanic eruptivity.
    A. Islands depressed so deeply that the tops of the andesitic hills were covered with limestone.

1) Islands with limestones eroded partly or wholly from the summits of the andesites.
   - Malatta
   - Avea
   - Thikombia-i-lau
   - Tuvuthá

2) Islands with volcanic rocks still covered with limestone.
   - Vekai
   - Fulanga
   - Ongea
   - Wangava
   - Vatoa

B. Islands whose tops were never covered by limestone.
   - Lakemba
   - Ono-i-lau

III. Volcanic islands of the second volcanic period built on platforms composed of coralliferous limestone overlying depressed hills of the first volcanic period.
   - Munia
   - Kanathea
   - Ono
   - Mbengha

For the purposes of discussion in this paper, the islands are grouped according to a simple plan as follows:—

1) Islands composed of both limestone and volcanic rocks.
   - Vanua Mbalavu, Malatta, Thikombia-i-lau,
   - Susui, Avea, Tuvuthá,
   - Lakemba, Ono-i-lau, Kandavu.
   - Kambara,

2) Islands composed of limestone alone.
   - Vekai, Ongea, Vatoa.
   - Fulanga, Wangava,

3) Islands composed of volcanic rocks only.
   - Munia
   - Kanathea
   - Ono-i-Kandavu
   - Mbengha

GROUP I. ISLANDS COMPOSED OF BOTH LIMESTONE AND VOLCANIC ROCKS.

Exploring Group.

Vanua Mbalavu
Malatta
Susui
Avea
Thikombia-i-lau

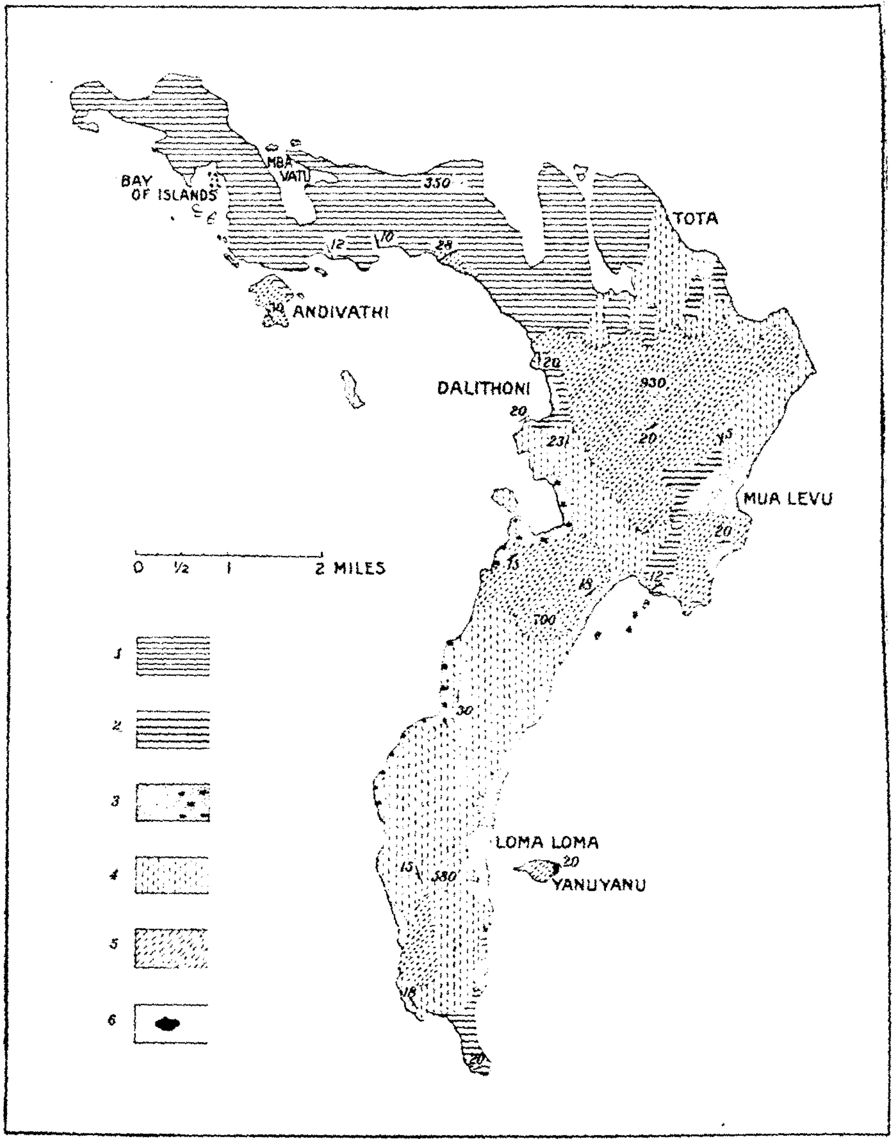

BAY OF ISLANDS
MBA VATU
350
TOTA
12
10
28
ANDIVATHI
10
DALITHONI
20
930
20
231
20
45
MUA LEVU
20
0 ½ 1 2 MILES
15
18
12
700
30
LOMA LOMA
20
YANUYANU
15
580
18
20
1
2
3
4
5
6

FIGURE 20. Geological Sketch Map of Vanua Mbalavu, Exploring Group. 1 — Coralliferous limestone. 2 — Basal calcareous conglomerate. 3 — Coastal sands and mangrove swamps. 4 — Andesitic lavas of the first period. 5 — Basaltic lavas of the second period. 6 — Ash deposits more ancient than the andesites.

The Exploring Group consists of six large islands lying about the border of a lagoon nearly 30 miles in diameter. All but one of the islands are composed of both volcanic rocks and limestone. The one exception, Munia, consists only of volcanic rocks and will be considered later.

Vanua Mbalavu. The largest island of the group, Vanua Mbalavu, is long, narrow, and shaped somewhat like a question mark. Its greatest length lies approximately in a north-south line. Its extreme northern and southern ends are composed of limestone, while its center is composed of volcanic rocks. As indicated in the accompanying map (Figure 20), the volcanic rocks form the greater part of the island.

The volcanic rocks were erupted in two different periods which will be called the andesitic and basaltic periods of extrusion. The andesites were eroded to late maturity. They were then submerged and coralliferous limestones were laid on them unconformably. Later they were uplifted with the overlying limestones and both were deeply eroded. During the later volcanic period, this eroded topography was buried beneath basaltic flows and ash-beds and the basaltic slopes, in their turn, have been eroded to maturity.

The late-mature hills somewhat south of the center of the island, near the village of Loma Loma, represent the older or andesitic period. They slope gradually to the south from an elevation of 300 to 400 feet, and disappear beneath the elevated coralliferous limestone which unconformably overlies the andesite. A few, very vesicular basalt flows of the later eruptive period occur in the extreme southwestern part of the island, but their source was not found.

Toward the north, at a point near the center of the large curve of the question mark, the slopes of the late-mature hills of andesite continue beneath the limestone. Just south of this point (near Tota) isolated patches of a shell and coral-rubble limestone rest unconformably on the andesite, and further south near the bottom of the curve (Mualevu) other isolated patches lie within a broad valley extending 2 or 3 miles inland. Near the northern edge of this valley, these patches are seen to be overlain by more recent basaltic flows and are colored red, probably due to baking.

Along the sea-coast on the western side of the island (Dalithoni), and near the northern contact of the volcanic rocks with the elevated limestones, there is a series of instructive exposures. A small bay is bounded to north and south by limestone headlands. The southern headland is composed of a foraminiferal limestone containing bits of andesitic ash. The limestone is 30 or 40 feet thick and dips eastward. It may be followed around the bay to the north, but its contact with the overlying rocks is not exposed. It is seen, however, to dip conformably beneath a layer of coralliferous limestone which forms the basal layer of the northern headland. The coral limestone is composed of coral heads in place, with reef rubble between, and is 5 feet in thickness. The coral heads form about two-thirds of the deposit. An agglomerate, 10 feet in thickness, overlies this deposit conformably. The agglomerate consists of large, angular coral-heads which occupy irregular positions, with angular boulders of vesicular andesite, 5 to 6 feet in diameter, fixed in a paste of andesitic ash and lapilli. This peculiar bed is overlain by 15 to 20 feet of a cream-colored coralliferous limestone which in turn is overlain by 20 feet of a pink coralliferous limestone. All the beds are conformable and dip 20° east.

The basal layers of the outcrops just described indicate volcanic activity at the time they were deposited. Yet the upper coralliferous limestone proved to be continuous with the elevated limestones of the entire northern part of the island, and those limestones unconformably overlie the maturely-eroded andesites to the east. Since coral heads in place occur in the northern limestone at an elevation of 350 feet, and also within the mass of the limestone at the bottom of the deposit just described, it is probable that subsidence to the extent of 200 feet, more or less, occurred during the deposition of these rocks.

These relations point to the conclusion that, at the close of the long period occupied by the erosion of the andesites and the development of coral reefs off-shore, new andesitic eruptions broke out, and that soon afterward the island subsided.

The discovery of a limestone layer, underlying later lavas on the eastern side of the island, has already been noted; further evidence of a later extrusive period is found along the northwestern side, within the large curve of the question mark. Flows of vesicular basalt follow the valleys cut in the limestone along this shore.

The small outlying island, Andivathi, is composed of andesitic agglomerates and ash, dipping 30° E. The western beds, representing the lower members of the series, are coarse agglomerate with vesicular blocks of lava, a foot or more in diameter. The upper beds become finer and finer and show many small fragments of pumice. The total thickness of the beds is about 200 feet. The eastern side of Andivathi is composed of elevated coralliferous limestone. Both ash and limestone are cut by a net-work of basic dikes. All the dikes are deeply eroded and their upward extensions are gone. The largest observed dike intruding the limestone is 20 feet in width. It is deeply lateritized and outcrops in a long, well-defined depression in the limestone which forms a perpendicular wall on either side, indicating that the volcanic rock here weathers more rapidly than the sedimentary.

On the northeastern side of Andivathi, ash-beds are seen to overlie the limestone, and to dip southeast towards the eroded and nearly vertical walls of limestone, lying just across a strait, not more than a hundred yards wide.

Again, at Mba Vatu, on the northeastern side of Vanua Mbalavu, thin dikes, about a half inch in thickness, were found intruding the elevated limestone at a height of 300 feet.

Near the center of the large curve of the question mark, a peak, (Koro Mbasanga), 920 feet high, was built up during the second volcanic period and the cone of which it forms a part has since been maturely eroded. This cone has been placed in the second period of volcanic activity, since (1) its lavas are of the basaltic type and unlike the lavas of the first or andesitic period; and (2) lavas traced from this center overlie foraminiferal limestone which rests unconformably on the andesites of the first period.

Scattered over the surface of the deeply lateritized hills of andesite are numerous silicified fragments of coral. It was noticed that the surface waters, carrying silica from the lateritized hills, were apt to deposit the silica near the contact of the limestone with the volcanic rock and it is supposed the silicified coral originated in this way. The presence of the corals indicates that considerable areas of the limestone have been swept away. Whether the andesitic hills of Vanua Mbalavu were ever wholly covered with limestone is not known, but since the elevated limestone now occurs at elevations as great as that of the highest andesitic hills, this is considered possible.

The coastal irregularities of the old andesitic hills, as well as the deep bays of the limestone portion of the island, have been appealed to as evidence of recent submergence. It does not appear to the writer that this evidence is necessarily conclusive. In the first place, the valleys cut in the andesite may have been formed before subsidence and, after the subsequent uplift, uncovered by the erosion of the unconformably overlying limestones. In the second place, the drainage passing from the andesitic hills beneath the limestone or percolating through the limestone to the andesitic contact, has produced effects peculiar to islands of this type. Much of the drainage passes by deep channels out to sea and appears, off-shore, as fresh-water springs. The persistence of these channels has led to the honeycombing of the limestone by immense caves. The roofs of the caves collapse and continued solution, followed by later water-action, create rifts in the nearly vertical walls surrounding a limestone island. The rifts then develop into fringing bays with almost vertical sides, extending far inland. It is believed that the deep bays in northern Vanua Mbalavu have been largely so formed.

Avea. Avea is an oblong island with its longest axis lying nearly northeast by southwest. It is 3 miles long and 1½ miles wide and has an elongated spit of sand to the southwest, as indicated in the accompanying map, (Figure 21).

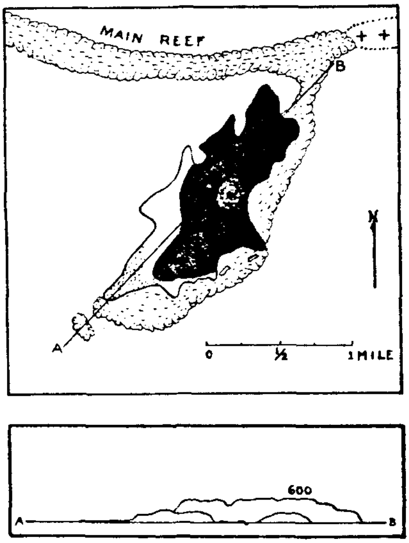


Figure 21. Sketch Map of Avea, Exploring Group.
Black — elevated coral reef. White — pyritized tuff. Dotted — sandy beach.

The oldest rock formation of Avea, seen on its northwestern side, is a brecciated, highly pyritized tuff, which was eroded into mature hills. After dissection, these hills were submerged and on them were laid down, unconformably, 310 feet or more of coralliferous limestone. The whole mass was later uplifted and eroded to an irregular island with a sharp, central ridge, with precipitous cliffs of limestone about its shore, except on the northern side, where the tuff is exposed. No exact contact was found between tuff and limestone; yet because the tuff deposits underlie the limestone and rise into it in a series of irregular domes, it is inferred that the history of the island must be as stated. Besides, the pyritization of the tuff must have occurred before the deposition of the limestone, since the latter rock is not pyritized.

Dips of 10° to 14° were seen in the limestones, but, since the limestones of the other islands rise to a uniform level, it is believed they have not been tilted, but rather were deposited at this angle. The same argument holds good for similar irregularities of dip indicated on the map of Vanua Mbalavu.

On the southern side of Avea, coral heads in place were found in small, secluded inlets along the precipitous coast. These heads are conformably overlain by coralliferous limestone. They are surrounded by a paste of coral and shell rubble, as in the present-day reefs. The coral heads indicate that a considerable subsidence must have followed their growth.

Yanu Yanu. The relation of the tuffs to the andesites is not clear from the occurrence at Avea, but is revealed by a study of Yanu Yanu, (see Figure 20). This island is almond-shaped with a sand point extending westward. The island is less than a mile in length and is cone-shaped. Its northeastern side is formed of tuff, visible in a cliff 40 to 50 feet in height. The original form of the deposit has been lost through profound erosion. It now covers an area of less than an acre. To the south the ash is intruded by an acid andesite, which cuts off its further extension in that direction. To the west, the main mass of the island, rising in a cone to an elevation of 270 feet, is composed of an olivine basalt of the second volcanic period, which intrudes and overflows the ash. The presence of these later rocks, surrounding the very loose and easily eroded ash, accounts for the preservation of the latter.

Malatta. The islands of Malatta and Susui, adjacent to Vanua Mbalavu, represent a continuation of the limestone mass forming the southern end of Vanua Mbalavu. This limestone mass has been separated into the three islands by the process of solution and outward drainage outlined above. The process is still continuing and the islands will undergo further dismemberment.

Malatta averages about 200 feet in height. Its interior is so roughened with solution pits that the island is practically impassable. About its shore-line, precipitous cliffs, 40 to 50 feet high, render landing from a boat very difficult. These cliffs break down only near the strait separating the island from Vanua Mbalavu. Just east of the strait, a series of low, late-maturely eroded hills of pyritized tuffs are overlain unconformably by 150 to 200 feet of coralliferous limestone.

Susui. The western end of Susui, east of Malatta, is composed of limestone. The two islands are separated by a tortuous passage, only a hundred yards wide, through which runs a violent tidal current. This portion of Susui is very rough, like Malatta. An inland lake occurs near the passage, which is filled as the tide rises, and the fall of the tide leaves the surface of the lake above sea-level. As a result, the waters from the lake, draining off through underground channels, rise in fountains off-shore within the intertidal zone.

The limestones of Susui rest unconformably on maturely eroded andesite, composing the central portion of the island. The surfaces of the andesitic hills bear silicified masses of coralliferous limestone similar to those found on Vanua Mbalavu, suggesting that the limestone once extended over these hills.

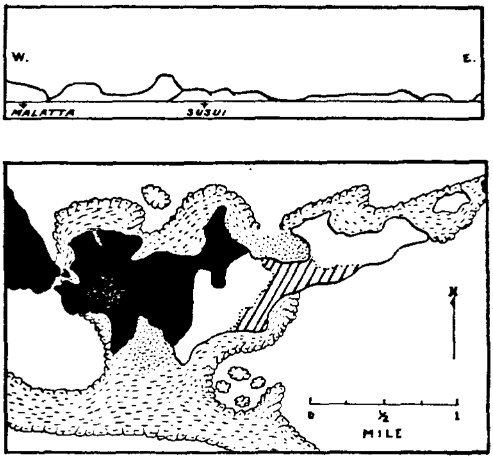


FIGURE 22. Sketch Map of Malatta and Susui, Exploring Group. Black — elevated coral reef. White — volcanic rocks. Lined — sand flats.

A low sand flat, stretching entirely across the island, connects the andesite with a series of basaltic rocks which form the eastern end of the island, (Figure 22). The basaltic formation is continued in a series of agglomeratic islands extending in a curved line to the northeast. Within the group of agglomeratic islands is one composed of limestone.

The basaltic rocks of Susui and the agglomerates of the outer islands are fresher than the andesitic rocks to the west. The dips of the agglomerates, closely adjacent to the limestone islet, indicate that these beds once surrounded the small island. The directions of dip indicate that the eruptive center lay in the eastern island, Munia. From these facts it is concluded that the basalts of eastern Susui were erupted after the elevation of the limestones of the Exploring group, and thus during the later volcanic period already seen to be important in the history of the group as a whole.

Scattered limestone islets lie within the lagoon, inside the curve formed by the three large islands of Vanua Mbalavu, Malatta, and Susui. On the northern border of the lagoon a few volcanic islands occur. The only other island of any size, except Munia which will be described later, is Thikombia-i-lau.

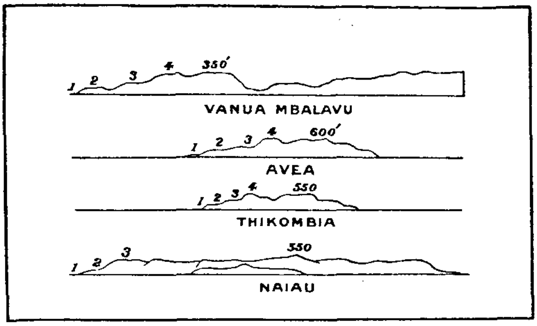


FIGURE 23. Profiles of Four Limestone Islands of the Lau Group. Numbers indicate possible terraces.

The accompanying outline sketches (Figure 23) were made at a distance from the islands shown, Thikombia-i-lau, Avea, Vanua Mbalavu, and Naiau. Five miles away, one would say immediately that the breaks in the outlines of the islands represent sea-cut benches, yet a closer view causes doubt as to whether they have significance or not. Many of the supposed "benches" represent a chance alignment of several cliffs and hills which cannot be traced with any regularity about the islands.

Thikombia-i-lau. Thikombia-i-lau is shaped like a Scotch bonnet with a central, north-south depression cutting entirely across it. The floor of the depression is formed of andesite; on either side rise coralliferous limestones.

The southwestern side of the island is a mass of andesitic agglomerate, in cliffs 80 to 100 feet high. The contacts of the limestone with the andesitic rocks are difficult to find. At observed contacts no shell conglomerate with inclusions of the andesite was discovered. But, since the limestone overlies large areas of agglomerate and ash and rests on a very uneven surface, it must be inferred that the volcanics were first deposited, later carved into mature hills, and then depressed and overlain by coralliferous limestones. The adjoining sketches (Figure 24) serve to show the areal distribution of the limestone and volcanic rocks and their relation to one another.

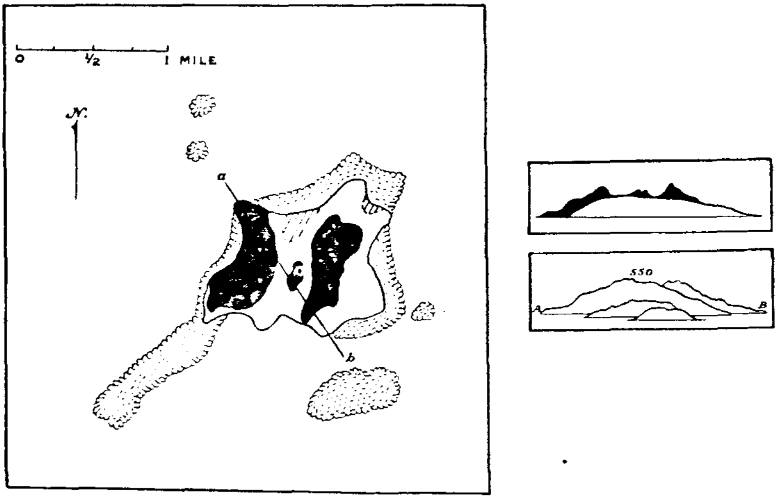


FIGURE 24. Sketch Map of Thikombia-i-lau, Exploring Group. Black — elevated coral reef. White — volcanic rocks. Lined — sandy flats.

Crossing the island from the small village at its southwestern corner, one first climbs to a bench, 75 feet above sea level. Then follows a steep rise to a second bench at 210 feet, and then a gradual rise to the central valley at 360 feet. The valley is a relatively level floor, a quarter of a mile wide, and extending for a mile or more through the center of the island. Precipitous cliffs of limestone, 200 feet high, rise on either side of the valley.

Though no embayments are indicated in the outline of the island, local, pocket-like, marine plains, formed in the process of coastal simplification, occur about the shore of the island and extend an eighth of a mile inland. These plains are often formed of bedded coral and shell rubble occurring 5 to 8 feet above the present sea level and dipping 10° to 12° seaward.

No definite evidence of the basaltic period of volcanic activity was found in the island.

General Remarks on the Exploring Group.

From the study of the several islands lying about the border of the lagoon of the Exploring group, it has been determined: —

1) That at the first discernible stage of the history, a series of tuffaceous rocks was intruded and covered by andesite, the volcanic terrane being of unknown form and extent;

2) That, during the erosion of this mass to late maturity, intermittent eruption of andesite took place;

3) That this eroded land was fringed with reefs;

4) That a period of subsidence followed, leading to the deposition of at least 400 feet of coralliferous limestone unconformably on the volcanic rocks;

5) That the composite mass was then uplifted, so that the limestones are now found 400 feet above sea level;

6) That the elevated limestones and andesitic hills were deeply eroded;

7) That later basaltic eruptions buried the limestones and andesites with ash, agglomerates, and flows; and

8) That there has been a long period of erosion during which much of the ash and agglomerate of the basaltic period, and much of the limestones, have been swept away.

The existing isolated islands doubtless did not represent the entire land area previous to the great subsidence. It is probable that a series of rhyolitic and andesitic hills once covered an area at least as large as that enclosed by the present lagoon. It was this surface which was submerged and over which was laid down an unknown amount of limestone. Most of the islands studied show that their tops were entirely covered by the limestone and it is inferred that at that time a bank of coralliferous limestone marked this portion of the Pacific Ocean. It cannot be stated whether the bank had the form of an atoll. Some of the higher volcanic peaks of Vanua Mbalavu may have risen above the surface of the bank, but the indications are that the andesitic hills were entirely covered by limestone. The submerged surface of this bank may or may not have been as flat as the present lagoon floor. The irregular surface of the sunken land would, initially at least, involve considerable variations in the depth of water on the shoal.

Subsequent elevation brought great masses of the coralliferous limestone above the sea. Much of this limestone has been swept away by atmospheric solution and wave erosion, as is shown by the isolated islets of limestone dotting the present lagoon. The depths within the lagoon and the distribution of the limestone remnants suggest the possibility that the present andesitic hills represent only the high points of the older topography; that the uplift only served to shallow the depths over the bank and not in all parts to elevate its surface above sea-level; and that the subsequent basaltic eruptions and long continued erosion have furnished material with which the lagoon floor has been smoothed.

During uplift the coral would continue to grow about the edge of the elevated limestone mass. When uplift ceased, the destruction of the limestone by atmospheric solution and wave cutting would go on apace. If these limestones were not protected by a reef during the Glacial epoch, they must have been rapidly eroded. Certain it is that the elevated coralliferous limestones have disappeared from the edge of the present reef and only isolated remnants remain within the lagoon.

The depths between the isolated patches of elevated limestone are exceptionally great when compared to the average lagoon depths. They reach 90 to 100 fathoms at the eastern border of the lagoon, depths too great to have been produced by wave-cutting. Submarine solution cannot be postulated for reasons which are well expressed elsewhere, (see Vaughan, 1914, p. 27; Daly, 1915, p. 231; Davis, 1914, p. 576). Submergence furnishes the only valid explanation.

Direct evidence is lacking on the question whether this submergence was due to actual subsidence or to a rise of the ocean level after the Glacial period. The re-distribution of the loose volcanic products emitted during the basaltic period of eruptivity, and the erosion of the basaltic cones to maturity have furnished material sufficient to level the lagoon floor to a considerable degree. Even today the lagoon floor has an exceptionally irregular topography but these irregularities may be residuals of the eroded topography of the andesites. Portions of the lagoon are fairly flat and the question arises whether this flatness has been induced by sedimentation, by wave-cutting, or by both. The lack of pronounced embayment of the basaltic islands, suggests that most of the period during which the basaltic cones were eroded to maturity has been one of comparative still-stand, yet there is no evidence that this period has been sufficiently long to level the lagoon floor.

The outstanding fact remains that the present barrier reef is developing on the remnants of a bank of coral limestone once elevated and eroded, and now submerged.

Tuvuthá.

The general features of Tuvuthá, about 20 miles south of the Exploring Group, are similar to those of Thikombia-i-lau. Precipitous limestone cliffs surround the island on nearly all sides. The accompanying map and cross-section (Figure 25) show the distribution of limestones and volcanic rocks, and their relation to one another.

Only for a short distance along the northwestern side of the island are volcanic rocks known to outcrop at sea-level. The highest peaks on the island are of limestone. The greater portion of the interior is a rough, heavily vegetated, limestone country eroded into weird forms by solution.

Descending the steep limestone cliffs by tortuous ravines covered with thick undergrowth, one is suddenly confronted by a barren andesitic ridge, lying in the center of the island. The ridge is half a mile wide and about a mile and a half long. It is deeply lateritized and, at the time it was visited, bore no vegetation because of drought. The ridge, 540 feet high, is surrounded by a circular moat. Outside the moat rises a continuous cliff of limestones. Limestone patches also overlie the andesite of the central ridge.

Tuvuthá, like Thikombia-i-lau, was formed by the mature erosion of an isolated volcanic peak. It was then submerged, overlain by limestone, and uplifted. The occurrence of olivine-basalts in a conglomerate near the sea-coast, and the irregularity of certain limestone-andesite contacts suggest that a second period of volcanic activity affected the island after its uplift, but full evidence for this conclusion is not forthcoming.

The contact of the limestone with the volcanic rocks of the interior shows the surface of the andesite to undulate in low, rolling hills.

The unconformably overlying limestone is shelly, and of a red color, because much impregnated by iron. The rain descending on the central volcanic hills is led away by underground channels along the contact of limestone and andesite. No rivers occur on the island. Only one fresh-water spring was found. This appears near sea-level at the contact of the limestone with the andesite, on the northwestern side. This method of drainage causes the replacement of the limestone by many of the elements carried in solution from the volcanic hills.

No pebbles of the underlying andesite are found in the shell limestone. However, the contact is considered to be unconformable for three reasons; (1) there is no evidence of thermal action of the andesite on the limestone; (2) the contour of the andesites beneath the limestones is that of maturely eroded hills; and (3) the texture of the andesite does not become finer near the contact.

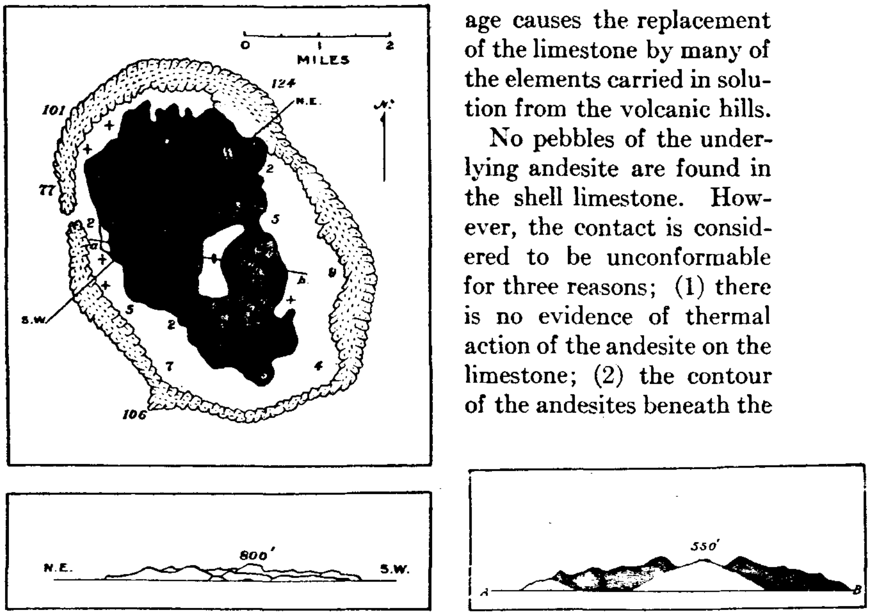


Figure 25. Sketch Map and Profile of Tuvuthá.
Black — elevated coral reef. White — volcanic rocks.

The contact of limestone and volcanic rock on the northern side of the island is less conclusive. It is true that a volcanic breccia, cemented by calcite, underlies the limestone and indicates erosion previous to subsidence, but elsewhere the contacts are so dike-like that it is difficult to imagine how an eroded surface could assume such forms. Reviewing all the evidence, however, it is concluded that the limestone, throughout the greater part of the island unconformably overlies the andesite.

Coral heads in place appear from top to bottom of the 590 feet of limestone; and in such relations that subsidence is the most logical explanation of their position. However, the greater part of the limestone is coral and shell rubble which surrounds occasional coral heads.

The depth of the lagoon about Tuvuthá is 6 to 8 fathoms, much less than the average depths of the lagoons of the Exploring group. As compared with the Exploring group, only a relatively small amount of upraised limestone has disappeared from the island. These facts suggest a more recent date for the uplift of Tuvuthá.

Lakemba (Figure 26).

Lakemba differs from the islands just described, in that the andesite forming its center was probably never overlain by limestone. The volcanic surface, reaching a maximum elevation of nearly 800 feet, is composed of well-rounded, mature forms. The rocks are deeply lateritized and support a scanty vegetation. The only fertile spots on the island are found along the lower portions of the stream courses, whither the best of the soil from the volcanic hills has been transported; or at the heads of the bays, where the coral sands produce an abundant coconut harvest.

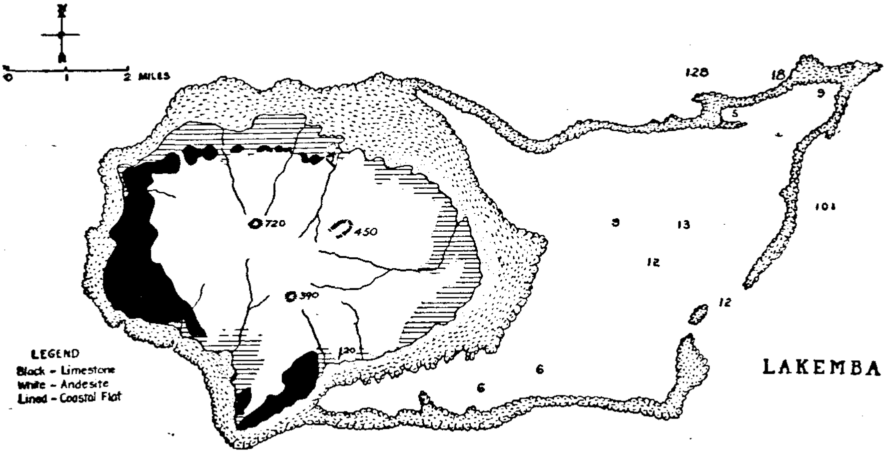


Figure 26. Sketch Map of Lakemba.

Along the boundary of the volcanic area are isolated remnants of elevated limestone which once encircled the island. Such remnants unconformably overlie the andesite and rise to a maximum elevation of 320 feet. A castle-shaped mass, with the height mentioned, occurs on the northwestern coast. A mile east of this locality, spur-ridges and their intervening valleys are covered with a mantle of shell and coral rubble mixed with volcanic pebbles up to an elevation of 100 feet. The diagram (Figure 27) illustrates the position of the limestone with respect to the andesite. The average dip of the contact between the andesite and the limestone is 18° N.; the dip of the conglomerate is 12° N.

Following along the coast to the southwest, the conglomerate sweeps inland and, toward the sea, is overlain by coralliferous limestone. The contact between the two deposits is transitional, as may be seen by tracing the conglomerate from its inland contact with the andesite to the coralliferous limestone cliffs near the sea. The same fact is revealed in the sea-cliffs; their lower portions are often formed of shell and coral waste bearing volcanic pebbles and passing upward into reef-limestone.

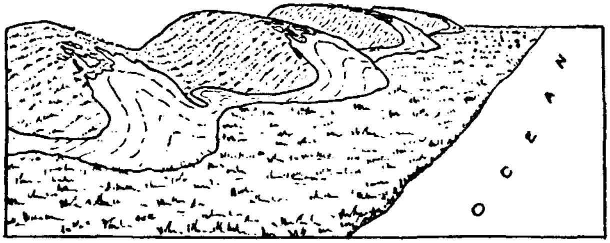


FIGURE 27. Sketch of Spur-hills, Northern Lakemba.

Peculiar drainage conditions obtain here. Descending the mature valleys carved in the andesite of the interior, one would naturally expect to reach the coast easily. In some instances this is true, but usually a wall of limestone, 75 to 100 feet high, cuts across the valley. Beneath the wall the surface waters run down amidst a collection of boulders swept from the andesite hills, and flow to the sea by underground channels, truly remarkable caverns. Many of the cavern roofs have collapsed, affording open passage-ways to the sea. To the southward the passage-ways have been widened until mere remnants of limestone tip the ends of the spur-ridges.

Thus, the island, bearing a number of andesitic cones, underwent mature erosion and subsided. The mature topography was not entirely submerged, since 400 feet of the island still remained above the sea. The sunken portion was overlain by 320 feet, or more, of coralliferous limestone, and was later uplifted.

The limestone remnants decrease in altitude along the coast towards the east and do not occur throughout the eastern third of the island. The disappearance may be explained in two ways. It may be due to more rapid solution on the rainy side of the island or it may be due to tilting during uplift. If erosion were the cause, it would seem that the rainy side should show a more mature topography than the dry side. It is, however, significant that the western side shows greater erosion than the east.

Again, the reef on the western side of Lakemba is narrow and fringing, but on the northeast it sweeps far out and includes a lagoon 8 or 10 miles wide. The width of the eastern reef suggests that it has either been long established or recently submerged. The western reef on the contrary appears to have been established in sub-recent times. Recent valleys cut in red clay at the southwestern side of the island support this conception, whereas the drowned valleys of eastern Lakemba indicate a tilting in that direction.

In this connection it is important to note that the Lakemba lagoon has a maximum depth of 14 fathoms; the Aiwa lagoon, 4 miles to the southeast, 21 fathoms; and the lagoons of the Argo reefs, 15 miles to the east, depths of 20 fathoms on their western side, of 35 fathoms on their eastern side. These depths are greater than the average for the Lau islands and may be attributed to the eastward tilting movement described above, (see table II, p. 93).

An outline of the geological history of Lakemba is as follows: —

1. Period of volcanic activity.
2. Period of erosion, carving to maturity the volcanic peaks formed in the first period.
3. Period of subsidence, during which 4 to 5 feet of conglomerate, 15 to 20 feet of shell sandstone, and 300 to 325 feet of coralliferous limestone were deposited unconformably on the andesitic surface.
4. Period of uplift in the western part of the island accompanied by tilting toward the east.
5. Period of erosion.

Ono-i-lau (Figure 28).

The accompanying chart presents the main features of the Ono-i-lau group. Near the center of the circular lagoon, about 6 miles wide, lie three large islands. These are arranged about a central depression which represents an eroded crater. The crater walls have been breached and dissected, their remnants being the islands, Ono Levu, Ndavura, and Ndoi. They are composed of interbedded andesitic ash, agglomerates, and flows.

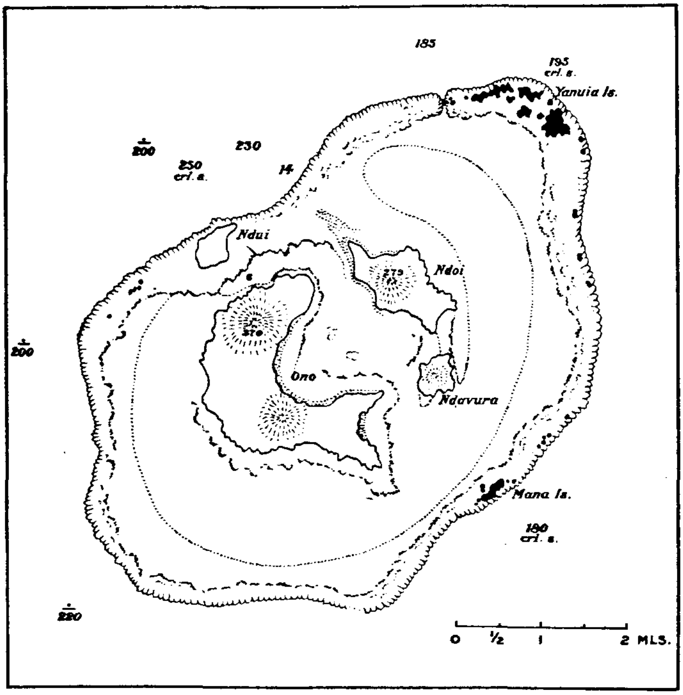

185
195
crl. s.
Yanuia Is.
200
230
250
crl. s.
14
Ndai
279
Ndoi
200
270
Ono
Ndavura
Mana Is.
180
crl. s.
220
0 ½ 1 2 MLS.

Figure 28. Sketch Map of Ono-i-lau.
Black — elevated coral reef. White — volcanic rocks.

About the border of the lagoon, close to the edge of the present reef, are groups of elevated limestone islets. The group at the northern border is known as the Yanuia islands; that at the eastern border, as the Mana islands. Elsewhere about the border, isolated toadstool islets appear; on the western side of the lagoon in the lee of the largest island (Ono Levu) a sand island, Ndui, has been built up.

Ono Levu represents the southern third of the old crater wall. It is crescentic in shape and at either end stand two flat-topped hills, between which there is a low sag. The flows and agglomerates composing the island dip outward from the central depression. They are cut by a series of dikes which radiate from the old crater.

The island has a low, rolling topography of late-mature hills of deeply lateritized andesite. Erosion goes on rapidly during heavy rains; the water runs from the hills in sheets rather than in streams, sweeping off layers of the lateritized soil.

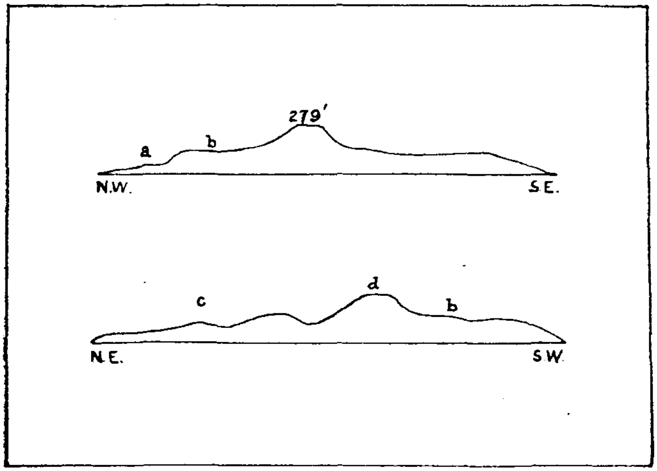


FIGURE 29. Profiles of Ndoi, Ono-i-lau.
a — Sand flat to leeward. b — Lateritized andesite flat at 100 feet. c — Hogbacks of andesitic flows. d — Central butte of agglomerate.

Ndoi shows outward dips and mature topography like Ono Levu. On its northern side a few hog-back ridges are composed of relatively resistant lava flows between the softer ash-beds. A well defined wave-cut bench surrounds this island at an elevation of about 100 feet. Though present in the other island, the bench is there not so well preserved. These features are illustrated in the outline sketches (Figure 29). On the eastern side of Ndoi the sea has cut in the agglomerates a platform 100 to 300 feet wide, at the present sea-level. The width of the bench indicates a crustal stability of some duration.

Yanuia, Mana, and other limestone islands about the border of the lagoon are largely composed of reef material in place. Coral heads often form 50 per cent of the visible limestone. The elevated limestone with its surface now 15 to 20 feet above sea, has been greatly etched by solution, with the generation of thousands of sharp points which make the surface nearly impassable. The dips of the limestone as taken on the Mana Islands were 18° and 11° S. and on the Yanuia Islands 15° S. E. Since there is no evidence of tilting in the group, these dips apparently represent original angles of deposition.

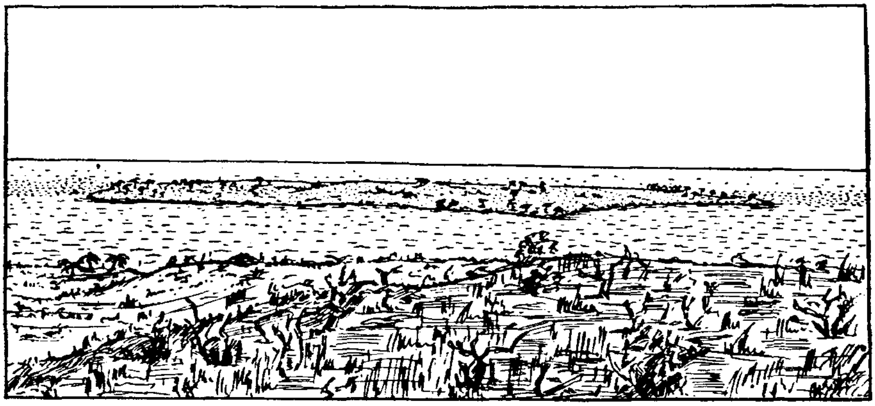


FIGURE 30. View of Ndui from Ono Levu.

The recurrence of the limestone islets at intervals about the edge of the reef seems best explained on the assumption that they are remnants of a more or less continuous mass of limestone, which has been largely destroyed and on which the present barrier reef has developed. Though no solid limestone is exposed in Ndui (Figure 30), the close proximity of limestone islets suggests the presence of a limestone basement beneath the sand. The prevailing easterly winds sweep the sand from the eastern side of the lagoon around the volcanic islands, and pile it against the western reef at its inner border, in the lee of the volcanic islands. Practically no coral grows in the lagoon near its western side. Sand flats, fordable at low tide, extend from the island out to the reef.

The Ono Group presents many similarities to Totoya, lying to the northwest, except for the lack of uplifted limestones in Totoya. The crater wall of Totoya is breached in only one place and is not broken into separate islands, as at Ono. The old crater of Totoya has an average depth of water of 28 to 29 fathoms, while the lagoon depths between the reef and the volcanic islands average 18 to 20 fathoms. This contrast is reversed at Ono, where the maximum depths within the crater are 6 to 8 fathoms and those in the outer lagoon are 8 to 10 fathoms.

The topography of Ono is of a type showing this island to be older than Totoya. The longer erosion has tended more completely to fill the crater depression with silts from the volcanic hills, as well as with debris from the eastern reef.

The 100-foot bench on Ndoi, already noted, may be correlated with the uplifted barrier reef and possibly the surface of the reef has been reduced by erosion from 100 feet to 10 or 15 feet in the period since the uplift. If so, the reduction of the lagoon depths by 100 feet, would be an important factor to consider in accounting for the present shallow water about the islands.

The Ono Group presents a good opportunity to compare known facts with theory. The remnants of elevated coral limestone stand approximately at the edge of the present reef. If the limestone originated in pre-Pleistocene times, they were elevated either before, or after, an inferred period of Pleistocene wave-cutting. If they were elevated before, it would seem that wave-cutting should have destroyed these evanescent forms near the edge of the reef. If they were elevated after the Pleistocene, barrier reefs, accepting the postulate that the corals are of pre-Pleistocene age, must have existed in pre-Pleistocene times; for the ordinary agents of erosion would hardly destroy the inner parts of a fringing reef and leave the outer in the form of a barrier reef. But the Glacial-control theory conceives that the existing barrier reefs and atolls are special forms of coral growth, developed on platforms cut in the Glacial epoch, and that they were much rarer before that epoch than at present.

However, the elevated limestones may have developed not in pre-Pleistocene but in Pleistocene or Recent times. It is possible that a bench was formed about the Ono Group by Pleistocene wave-cutting; that a barrier reef grew up about the islands, with the return of the waters after the Glacial epoch; and that, later, the barrier reef was uplifted.

If this hypothesis be true, a number of events must have occurred since Pleistocene times. There must have been a period of still-stand during which the barrier reef was formed and a bench cut in the volcanic rocks of the central islands. This period was followed by one of uplift. Since then, the inner bench has been largely destroyed, the elevated limestones reduced from 100 to 10 or 15 feet, and a bench, 100 to 300 feet wide, cut in the volcanic rocks at the present level. The rapidity of subaerial erosion in the South Sea islands allows the writer to believe that such a series of events is not impossible in the time postulated.

If the barrier reef were formed by subsidence according to Darwin's theory, it would be important to know the amount of the subsidence. The prevailing slopes of the volcanic flows interbedded with the agglomerates today, average between 12° and 15°. The barrier reef, in developing from a fringing reef, would probably not build itself up vertically, but as this method of formation would give the maximum value for the subsidence, the calculation will be made on this basis.

The barrier reef is now on an average 1½ miles from the volcanic hills. A fair average of the slope of the original hills would be 15°. From these data the maximum amount of subsidence is calculated to be approximately 2000 feet. The outward growth of the reef and the erosion of the central volcanic hills would tend to reduce the figure for the subsidence; so that the actual subsidence necessary to produce the present barrier reef by Darwin's theory would be well under 1500 feet.

That Ono should subside 1500 feet is not at all incredible in view of the great subsidence of the larger islands; yet this hypothesis involves the nearly complete filling of the lagoon.

The persistence of frail islet masses of uplifted limestone, near the edge of the Ono reef, forces one to the conviction that the waves are very impotent just behind a barrier reef, and that their cutting cannot have significantly enlarged the present lagoons.

Kambara (Figures 31 and 32).

Kambara offers one of the most puzzling problems found among the smaller islands. It is an oval mass of limestone, 6 or 7 miles long, 3 to 4 miles wide, and surrounded by precipitous cliffs on nearly all sides. An irregular ridge, about 200 feet high, follows the nearly circular shore-line. The inner slopes of the ridge converge toward the center of the island, where the elevation approximates 80 feet. The limestone mass is therefore basin-shaped. The seaward cliffs are usually unscalable. Access to the interior of the island, is however, possible by way of local solution pits in the limestone. The interior is honeycombed with pits and caverns. Here and there a flat area of an acre or so is covered with a red, residual soil on which the natives grow coconuts. Some of the caverns extend below sea-level and in them the tide rises and falls.

On the seaward face of the enclosing ridge there is frequently a bench at an elevation of 100 to 125 feet. The general dip of the limestone forming the cliffs at the northern side of the island is 10° to 12° outward. The rock is composed of coral heads in place (forming nearly 30 per cent of the whole) and coral and shell rubble. Corals in place were found within the dissected mass at sea-level. There is no evidence of a volcanic substructure in Kambara even within its low interior basin. It is believed, therefore, that the visible island essentially represents a single mass of limestone, in places 350 feet high. There is no structural evidence that the coral-liferous limestone is a veneer on older Tertiary limestone. The observed attitude of the bedding shows the limestone to be everywhere conformable and of low dip. The conclusion follows that the island was formed by subsidence.

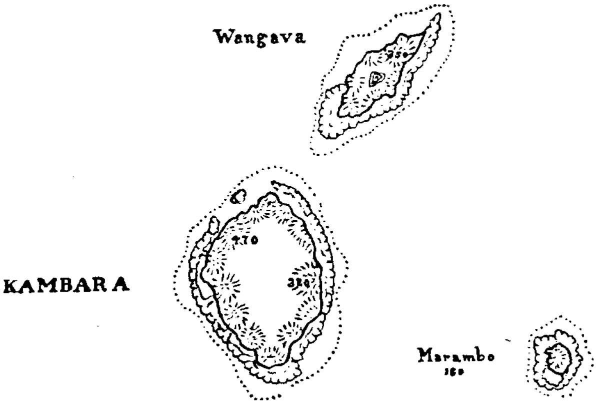


FIGURE 31. Sketch Map of the Islands of Kambara, Wangava and Marambo.

The main puzzle of the island is connected with its volcanic rocks. Although no igneous-rock basement is exposed, a hill, Ndelai Yaloi, 350 feet high, at the northwestern corner of the island, has been found to be composed of basalt, rich in olivine. J. Stanley Gardiner, (1898, p. 464) states that the "basalt, which has apparently welled out from a fissure near the base of the limestone cliffs — gradually increased in height, so as finally to overflow them and form a high hill."

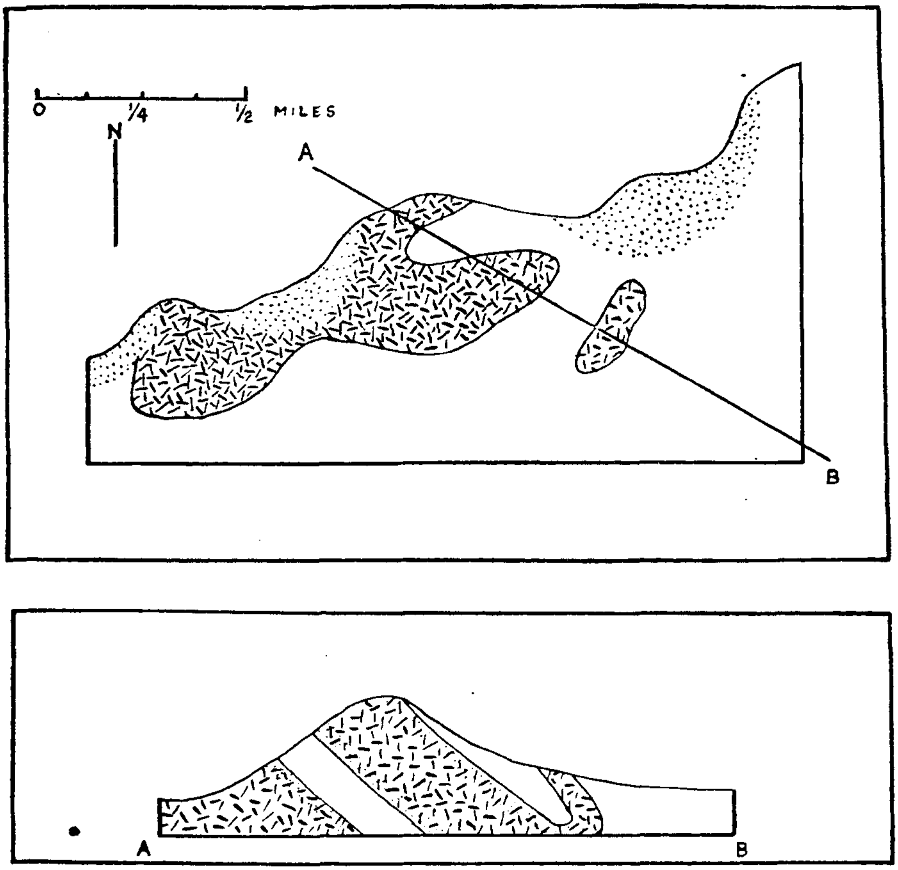


FIGURE 32. Sketch Map and Profile of Ndelai Yaloi, Kambara. White — elevated coral reef. Dashed — intrusive dike of basalt. Dotted — sandy flats.

The author studied the basaltic body (see Figure 32) and concluded that it was a dike, but saw no direct evidence of out-welling flows. The summit of the hill represents the outcrop of the dike. The coarsely vesicular character of the mass would indicate that the injected mass was here close to the surface. The dike is the more remarkable for this very fact. It is 250 to 300 feet thick, strikes about N. 70° E. and dips 55° S. E. It may be traced for 600 to 700 yards along the northwestern side of the island. Limestone was seen on both hanging wall and foot wall. There was no evidence of contact alteration of the limestone. The vesicles of the contact basalt are large and very fresh-looking. If they had even been subjected to water circulation below the sea-level, they would probably have been filled with calcitic or chalcedonic amygdules, but they were found to be entirely empty. The freshness of the rock as a whole and the absence of amygdules point to the probability that the dike was intruded later than the uplift of the island.

The question arises whether the dike magma ever reached the surface. The dike projects as a lone ridge, the highest point on the island, and dips away inland, presenting a steep escarpment to the sea. The face of the escarpment is the continuation of a very straight line of limestone cliffs forming the northern side of the island. It is believed that the surface outflows from the dike, if they ever existed, are invisible because faulted beneath the sea. The down-faulted block includes a small, northern sector of the original island, measuring about one mile in length and a quarter of a mile in width. The faulting postulated is suggested by: —

(1). The regularity of the northern face of the island across both limestone and volcanic rocks.

(2). The existence of a parallel escarpment on the adjacent island of Wangava.

(3). Depths reaching as much as 150 fathoms at points close to the shore.

(4). The abrupt termination of the barrier reef on the east and the west.

(5). The improbability that the long scarp is a wave-cut cliff, since it is situated on the leeward side of the island and since a distinct wave-cut bench at the foot of the scarp is lacking.

It appears, therefore, that after the uplift of the island, the dike was intruded and then the island was diminished by down-faulting on the north.

The reef about Kambara is fringing for most of its length, but has the barrier relation on the northeastern and northwestern sides of the island, where it projects as two short horns.

The writer's general impression is that the island has been elevated quite recently. The fringing reef is regarded as a simple outgrowth about the edge of the elevated island. The barrier reef at the northeastern and northwestern sides of the island may be connected with subsidence connected with the down-faulting of the northern side.

GROUP II. ISLANDS COMPOSED WHOLLY OF LIMESTONE.

Introduction.

A considerable number of islands show outcrops of limestone only. It is reasonable to suppose that in each case, volcanic rocks exist at no great distance below the surface and have not been uplifted above sea-level or, if so, have not been exposed by erosion. The presence of sideritic veins cutting the limestones, veins probably deposited by hot-spring action, tends to support this view. Kambara, the island just described, lacks exposure of its volcanic basement, but its limestone has been intruded by basalt; this relation is an exception to the rule that most of the islands which show large masses of limestone without an exposed volcanic substructure, have not been affected by the later period of volcanism.

What forms characterized the limestone masses before they were uplifted? Were they atolls? This question will be discussed after the facts concerning the islands, described by some as elevated atolls, are stated.

Wangava (Figure 31).

Wangava is one of the least dismembered of all the limestone islands visited. Naiau presents similarities in form, but this island was only seen at a distance.

The following sketch of Wangava (Figure 33) as seen from the northern shore of Kambara, illustrates its flat aspect, visible from practically any direction. The writer visited only the northwestern side of the island.

Wangava is 5 or 6 miles in diameter. It is surrounded by an elevated rim with precipitous cliffs about the coast. Its interior is basin-shaped and marked by numerous pits and caves similar to those of Kambara. The island has another feature not seen at Kambara, a central lake, three quarters of a mile across. The tide rises and falls in the lake about which toadstool islets of limestone stand and steep cliffs 75 to 100 feet in height rise about its edge. The depth of the lake varies. Near its shore and for some distance out it is only 4 to 5 feet deep and its bottom is covered with a black vegetable mold. In places, however, the bottom cannot be seen. From statements made by the natives the average depth near its center appears to be 3 to 4 fathoms.

There are many underground caverns about the edge of the lake and certain of these undoubtedly connect it with the sea. At one point on the northern side, there is a depression in the rim of the island and the limestone beneath is shattered, though there is no wide opening. The depression is probably due to the collapse of a cavern roof.

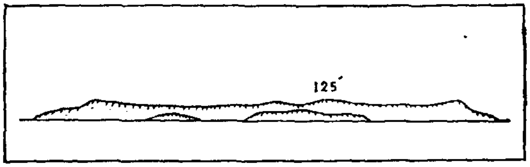


FIGURE 33. Profile of Wangava as seen from Kambara.

The limestones collected show that re-crystallization has gone on extensively near the center of the island and to a smaller degree near its edge. Sideritic veins and pockets abound. The limestone is composed mostly of coral rubble and shell waste. In fact no good examples of coral heads in place were seen, even in the rim of the island.

As already noted, the northwestern shore of Wangava has a fault-scarp parallel to the one described in Kambara. There are depths of 100 fathoms close to the shore; no reef exists on this side of the island and the coast-line is very regular. It is inferred that the fault which affected Kambara, affected Wangava also.

The narrowness of the fringing reef about the other sides of the island suggests, as at Kambara, the recency of the establishment of the present shore-line, presumably by uplift. If a platform had been cut during the Pleistocene period, the recency of the uplift would imply that this bench should now be above sea-level since the island has been uplifted 350 to 400 feet, an amount greater than the supposed rise of the ocean due to the return of Glacial waters. The upper surface of the island could alone represent the Pleistocene platform, for only minor benches are found about the edge of the island above sea-level. If the island represents an atoll which developed on a Pleistocene bench, the bench must be above sea-level according to the Glacial-control theory. In this case the Recent atoll must be assumed to have completely welded itself upon an older limestone mass; for no evidence of unconformity was found.

Ongea (Figure 34).

Ongea differs from Wangava in representing a later stage in the dismemberment of an elevated mass of coralliferous limestone. Two islands lie within the lagoon of Ongea. The southern one, Ongea Ndriti, was not visited. Ongea Levu has a wide, fingering bay indenting its southern side, which is transformed into a sand flat at low tide.

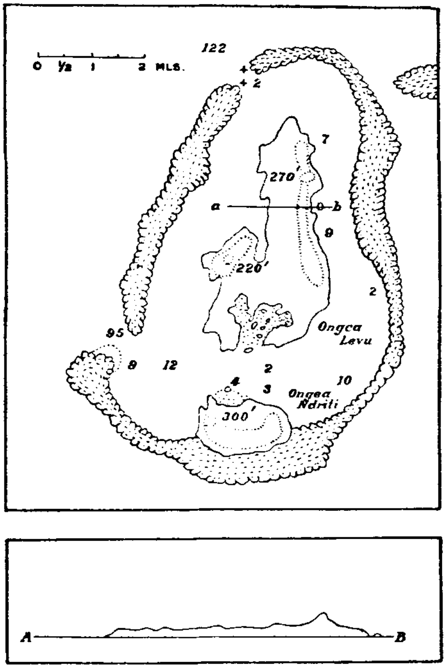


FIGURE 34. Sketch Map and Profile of Ongea.

This flat is covered with toad-stool islets whose overhanging ledges are 4 to 5 feet above the surface of the flat and project 8 to 10 feet from the main body of the rock.

As shown in the accompanying sketch map and cross-section (Figure 34) a narrow, steep-sided ridge, 270 feet in height, runs along the eastern side of the island. A dismembered ridge, 220 feet high, is located on the extreme western side. Between the ridges there is a flat, pitted plain, dotted with caves. The roofs of the caves bear stalactites and often one portion has collapsed, leaving the other portion as a niche in the side of a cliff. East of the seaward base of the eastern ridge, a flat 500 feet wide occurs at an elevation of 10 to 15 feet above sea-level.

There exists, therefore, in Ongea a flat, central plain at a slight elevation above the sea which has been produced largely by atmospheric solution. If the ocean level should rise but a few feet, this plain would be converted into a region similar to the sandy plain at its southern border. Neither atmospheric solution nor wave-erosion within a lagoon can, however, produce a level surface of this type 10 to 11 fathoms below sea-level. In other words, the present lagoon about Ongea must have been submerged since its formation. As the elevated corals are Pleistocene or Recent in age, it is believed they were uplifted in post-Pleistocene time, and hence the lagoon flat about the island cannot be ascribed to Pleistocene wave-cutting, nor the depth of the water above the flat to the rise of the ocean after the melting of the Glacial ice. A recent period of subsidence is, therefore, inferred.

Vatoa (Figure 35).

Vatoa, or Turtle Island, is an isolated mass of limestone lying 50 to 60 miles south of the Ongea Group. The single island within the reef resembles Ongea Levu in structure, as is shown by the following cross-sections (Figure 35). There are high ridges on the eastern and western

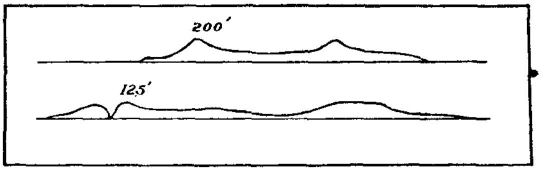


FIGURE 35. East-West and North-South Profiles of Vatoa.

sides of the island and between is a low, pitted plain. A sea-cut bench at an elevation of 10 to 12 feet is well defined along the northeastern side, but disappears to the south, where its absence may be due to more active atmospheric solution or to a tilting of the island. An extensive sand flat projects southward as a long reef-point which would perhaps suggest that the latter view is correct.

Dismembered portions of the elevated limestone mass of Vatoa dot the lagoon about the island. They have largely disappeared from the eastern coast, probably because of the greater abrasive efficiency of the lagoon sands to the windward. In the western lagoon they are found within 300 yards of the edge of the barrier reef.

The northern end of the island is in process of dismemberment from the southern part. A strait 20 to 30 feet in width separates the two remnants. This strait is bare at low tide and the basin-shaped depression near its center contains a pool filled with small coral heads.

There is no good passage across the reef at Vatoa. The anchorage is a protected bay in the reef to the westward. In rowing across the reef flat and lagoon to the main island a generalized section was drawn which holds good for most of the reefs studied (Figure 36).

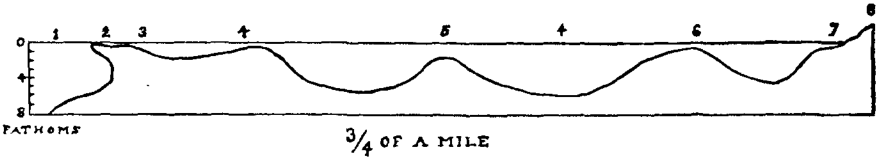


FIGURE 36. Typical Cross-section of a Barrier Reef.

(1). Sandy platform at an average depth of 7½ fathoms with some coral waste.

(2). Overhanging ledge of honeycombed coral through which are openings looking down into the depths. Mushroom heads of coral.

(3). Holes in the coral formation are here filled with sand. Coral growth is less abundant and stag-horn coral prevails.

(4). The sand increases in amount till the flat is nearly barren of coral and in the lagoon only an occasional head is seen.

(5). Coral patch with fairly vigorous growth of rounded heads.

(6). Bar connecting toad-stool islets; coral growth is here vigorous.

(7). This zone varies with conditions. If the lagoon is wide and the sand, carried back across the barrier reef, settles before it reaches this zone, a fringing reef develops; otherwise a sandy bottom is found.

(8). Elevated bench of coral and shell debris cast above high-tide level and often cemented into well-bedded limestones. This bench usually gives evidence of seaward growth.

Fulanga (Figure 37).

The island of Fulanga lies a few miles to the west of Ongea and 80 to 90 miles south of Lakemba. Within an encircling rim of elevated limestone lies a beautiful bay of islands for which Fulanga is noted. These undercut islets of varying sizes number from 300 to 400. The boat passage giving entrance to the bay is but 80 yards wide and one or two fathoms deep. Through it passes a strong tidal current, making the entrance very difficult even for small boats.

The surrounding rim of limestone is breached at several places along its northeastern portion, but elsewhere it is continuous. Forming the backbone of this rim is a ridge 125 feet to 250 feet in height with precipitous cliffs on its inner and outer sides. These cliffs are dotted with niches, the remnants of collapsed caves still festooned with stalactites.

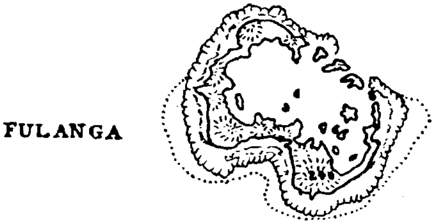


FIGURE 37. Sketch Map of Fulanga.

The small islets within the bay vary in height. The larger are 150 feet high; the smaller, because of undercutting and solution, rise only a few feet. Between the islets the depths vary from 1 to 6 fathoms and at one place somewhat west of the center of the bay, 10 fathoms is recorded. J. Stanley Gardiner, (1898, pp. 457 and 471) has referred to the island as an elevated atoll, but as in the case of Wangava, the central depression may be due to the more rapid erosion in the center of an elevated coral bank.

The writer visited the outer side of the rim along its western shore. Sand flats extend well up to the foot of the retreating central ridge.

At the foot of the cliffs lie abundant blocks of the limestone, fallen from the collapsed caves in the cliffs. As might be expected, the limestones here are greatly recrystallized. No large masses of coral heads in place were seen.

On the inner side of the rim, along the northwestern horn, sandflats lying 3 or 4 feet above high-tide level finger into the base of the central ridge. About the flats are many pinnacles of limestone. A slight submergence would allow undercutting to progress and the pinnacles would be transformed into islets similar to those dotting the central bay.

Where evidence could be secured, the cliffs at this side of the rim appear to be largely composed of material like that in the cliffs of the outer rim (coral and shell rubble). But at one place, back of the village of Navindamu, a lense of coral heads in place, 5 or 6 feet thick and 150 to 200 feet long, is clearly discernible. At the base of the deposit, which lies 10 feet above sea level, are 2 to 3 feet of sandy débris containing bits of shell and coral, loosely cemented. This bed is overlain conformably by 4 to 5 feet of coral-head limestone. A paste of the underlying, sandy deposit fills the interspaces between the heads. None of these deposits was cemented, while overlying them were 150 feet of much re-crystallized limestone, so compact that its texture can barely be made out. An occasional fragment of coral or shell is discernible; otherwise original structures have been obliterated.

The dips of the limestone taken at several points along the inner and outer side of the rim are 8° N., 10° N., 5° E., and 12° N. No evidence of tilting was seen in the island, and it is inferred that these dips represent the original angles of deposition.

The present reef is fringing for the greater part of the circumference of the island, though shallow lagoons, slightly over a fathom in depth, occur at intervals. The continuous shifting of sands within the inner bay makes it a poor habitat for corals, and few develop there. The sand is also a factor in the under-cutting and slow destruction of the central islets.

Much of the reasoning with regard to the origin of the islands of Ongea and Vatoa applies to Fulanga. The depths of the central bay indicates submergence. The narrowness of the surrounding fringing reef points to a recent shift of the sea-level. Atmospheric solution has so far dismembered the island that only a part of its rim now remains, together with an occasional bit of its center, over which the water is now, in general, 6 to 10 fathoms deep.

Vekai.

The island of Vekai represents almost the final stage in the destruction of an elevated bank of coralliferous limestone by atmospheric solution, the transformation of the resulting platform into an atoll by submergence, and the upgrowth of corals about its edge. Vekai reef is slightly over 2 miles in diameter. No portion of its rim has been aggraded above sea-level. On its eastern edge three or four remnants of a dismembered island of elevated limestone rise out of the ocean. None of these remnants is over 15 or 16 feet in height and their combined area is less than an acre. The limestone is so re-crystallized that nearly all its original structure is lost. It is extremely brittle, rings under the hammer and contains a considerable amount of magnesia. The surface of the islets is so rough and jagged that walking is dangerous. A few more centuries of undercutting and solution will destroy them completely.

GROUP III. VOLCANIC ISLANDS.

Introduction.

Between the large islands of Viti Levu and Vanua Levu, and the Lau Islands on the east lies a group of purely volcanic islands, namely, Koro, Mokongai, Wakaya, Mbatiki, Nairai, Ngau, Moala, Totoya and Matuku. None of these islands was visited. Koro was seen from a distance and appeared to have certain resemblances to Taviuni. Several of the islands of the Lau group are wholly volcanic. The largest of these are Kanathea, Munia, Olorua, Mothe, and Komo. Only Kanathea and Munia were visited.

Of the islands more or less closely associated with Viti Levu and Vanua Levu, Ovalau, Mbengha, Kandavu, and the Yasawa group are mainly volcanic. Of the Yasawa group, Yasawa-i-lau alone is composed of elevated limestones. Though previously unknown, it was found that the volcanic rocks of a part of Kandavu are underlain by limestones.

The stay on Ovalau was so brief that little geological work was possible. The island appeared to be a volcanic cone in a sub-mature stage of erosion.

The islands to be described are the following:— Munia, Kanathea, Mbengha, and Kandavu.

Munia.

Munia is the one remaining member of the Exploring group not described. It differs from all the others in that it has no limestone in its composition. The island belongs to the last or basaltic period of volcanic activity and is believed to have been built on an eroded bank of elevated coralliferous limestone and volcanic rocks.

Munia is elliptical in shape, its main axis directed northeast-southwest. It is composed of interbedded layers of agglomerate and ash which have been deeply eroded. A central ridge, 950 feet high at its summit and flanked by retreating cliffs, runs northeast through the island. The ash-beds exposed in the face of the eastern cliffs dip 20° to 30° E. In the rainy season land-slides from the cliffs are not infrequent. The slopes at the northeastern side of the island, are gentle and follow the initial dip of the volcanic rocks. At the extreme northeastern end of the island the deposits are nearly all ash.

On the southwestern side of the island, a depression appears to represent an old crater. Along its inner slopes the dips of the volcanic beds are quaquaversal and slope in every direction except to the north and northwest, where the crater walls have been destroyed. In describing Susui, an adjacent island, it was stated that the eastern end of that island is formed of agglomerates which dip westward and had their origin in Munia. Remnants of the original western slopes of Munia are also to be found as dismembered islets about the lagoon. The following map and cross section (Figure 38) illustrate the type of land form developed in Munia. The eastern slopes are clearly erosional forms but probably the western side of the island was destroyed by explosive violence, merely supplemented by erosion.

The volcanic débris, erupted from the crater in Munia and now composing the eastern part of Susui, overlies elevated limestone. For this reason Munia has been placed in the recent or basaltic period of eruptivity of the Exploring group. The recency of the volcanic action is attested not only by the topography but also by the slight lateritization of the basaltic agglomerates. While lateritization has extended to a depth of 20 to 30 feet in the andesitic rocks of Vanua Mbalavu, the maximum observed depth in Munia is but 2 or 3 feet.

The shore-line of Munia is little indented and gives slight indication of recent submergence. On the contrary, a recent uplift is suggested by the fact that some floors of the mature valleys are trenched by small streams to depths of 5 to 8 feet.

The formation of a volcano on an eroded mass of elevated limestone

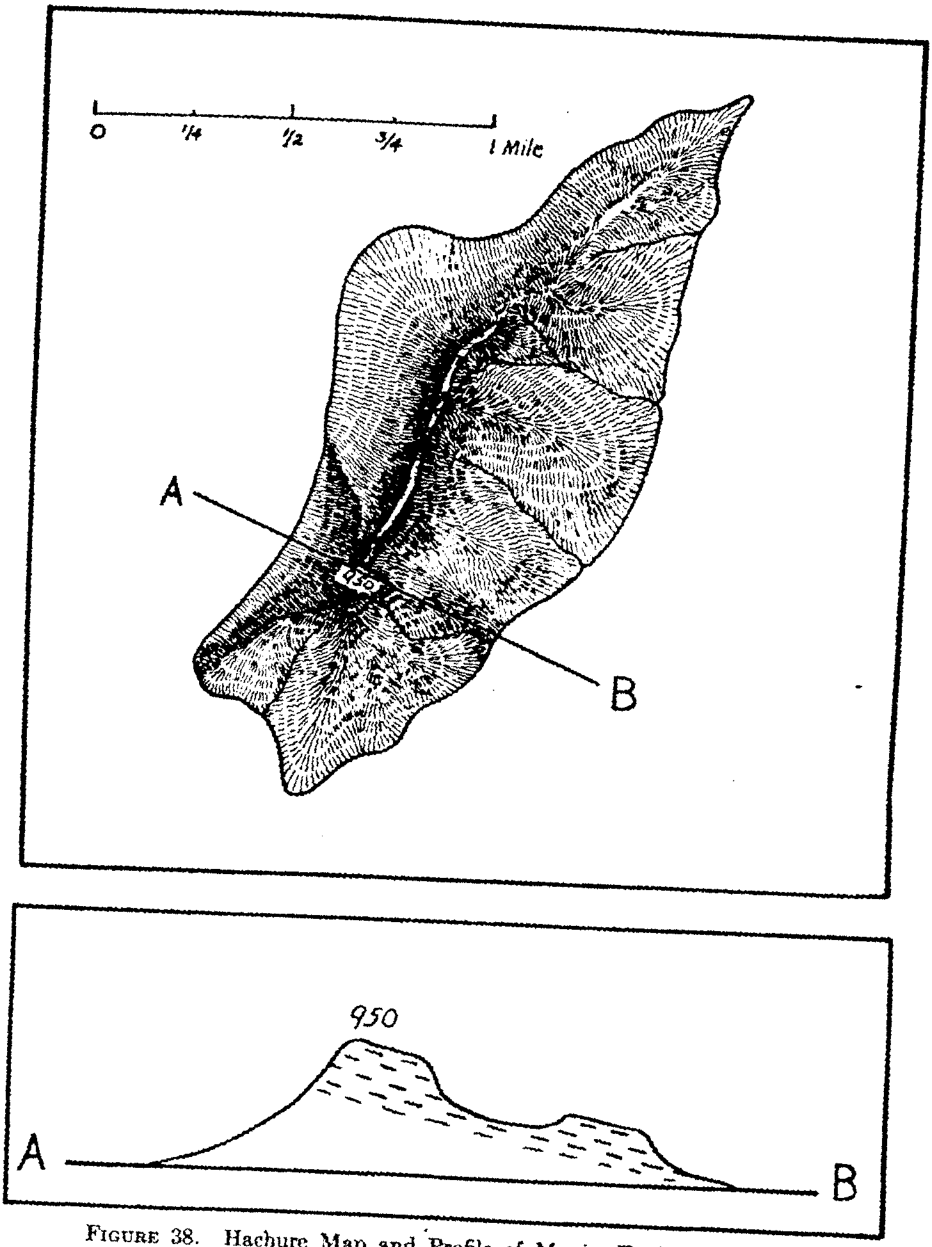

0
1/4
1/2
3/4
1 Mile
A
950
B
950
A
B

FIGURE 38. Hachure Map and Profile of Munia, Exploring Group.

and the erosion of the volcano to maturity require much time. It has been inferred that the planation of the elevated limestones of the Exploring group by wave-cutting may have occurred in the Glacial epoch. If Munia existed at that time, its slopes should have been cut by deep valleys and the valley-mouths should have been drowned at the close of the epoch. Since, however, the embayment of the coast of Munia is very slight, it is believed that the island was formed in late Glacial or early post-Glacial time; yet at a time sufficiently remote to permit of the mature erosion of the volcano. The elevated limestones underlying the débris from Munia are Pleistocene or Recent in date and hence confirm the evidence just given.

Kanathea.

The main portion of Kanathea is built on the remnants of an older, eroded volcano. Such remnants are still visible. No limestones appear; if they ever formed part of the island mass above sea, they have been lost by erosion.

The more recent part of Kanathea is built up of agglomerates and flows which have been carved into a sub-mature topography. The northwestern slopes of the island are little dissected and the slopes generally follow the initial dips of the volcanic beds. The eastern or windward side of the island has, however, deep, mature valleys.

The southern third of Kanathea is genetically distinct from its northern portion, and apparently represents a relic of the older volcano. Whereas the northern area is lateritized to a depth of but 2 or 3 feet, the southern has a late-mature topography of rounded hills, lateritized to depths of 15 to 20 feet.

Through northern Kanathea a central depression crosses the island from northeast to southwest. Entering this depression from the northeast, precipitous cliffs of agglomerate, 200 to 300 feet in height, are seen on either side. The dips of these beds are quaquaversal from a point somewhat east of the center of the valley. The lack of any streams competent to erode such cliffs and the quaquaversal structure of the agglomerates indicate that the central depression represents a crater. This crater has been breached.

A glance at the chart of Kanathea will show that the island has a long, narrow barrier reef extending to the northeast towards the Exploring group. The lagoon within the barrier reef is free of islands and has an average depth of 10 to 15 fathoms. The barrier reef ranges along the eastern and southern sides of the island; elsewhere the reef is fringing.

If an island existed here during the submergence of the andesitic hills of the Exploring group, it is reasonable to suppose that this island participated in that submergence. From the great amount of limestone which has been eroded from Vanua Mbalavu since the uplift of this formation, it is probable that the older volcano of Kanathea lost all its limestone veneer before the building of the more recent portion of the island.

The coastal outline of the newer portion of Kanathea, like that of Munia, is comparatively regular and shows little evidence of recent submergence. In fact, as at Munia, recent uplift is suggested by the incision of youthful valleys in the floors of the mature valleys of eastern Kanathea.

The history of the island of Kanathea is thus seen to be not unlike that of the Exploring group.

Mbengha.

The island of Mbengha is far removed from Kanathea, but many of its features are so similar that they will be discussed in the light of facts gathered at Kanathea. The reef about Mbengha is elliptical in shape, its longest axis extending northeast by southwest. The lagoon is 16 miles long and 10 miles wide. In its northwestern part lies Mbengha, a circular island four miles in diameter. The island is composed of agglomerates and flows of augite and hornblende andesite, carved into sub-mature topography.

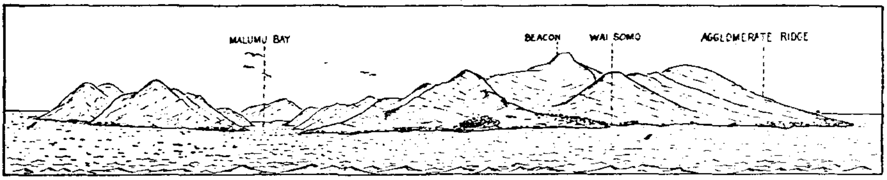


FIGURE 39. View of Mbengha as seen from the Northeast.

The northwestern slopes are long and even, following the original dip of the andesitic flows. The preservation of these slopes is probably due to the small rainfall on this side of the island.

The accompanying sketch of Mbengha (Figure 39), made from the northeast, shows the sharp peaks of its central portion and the deep bay of Malumu indenting its northeastern side. The bay represents the floor of an old crater. The high peaks at the western side of the bay are the edges of flows dipping away from the crater. Ash-beds which form the hills to the east of the bay also show quaquaversal dips.

Looking from the Beacon, the highest summit in Mbengha, towards the bay, several minor hills may be seen rising within the depression. As seen from the north, these hills appear to enclose the southern side of the bay, but actually the depression encircles the hills and a very slight subsidence would cut off the eastern side of the island and transform the hills into islands.

Other irregularities in the coast are believed to have an origin similar to that of Malumu Bay. They are irregularities, formed by the rapid erosion of weak ash-beds, and were not formed by the embayment of river valleys. The streams entering these bays are torrential, with boulder-covered beds within a hundred yards of their mouths. The evidences of embayment do not warrant the assumption that the island has subsided to any great extent; certainly not enough to support the view that the subsidence of Mbengha has converted a former fringing reef into the present barrier reef.

It has been shown, in the chapter on Viti Levu, that the larger island has experienced a number of earth movements, during which a lagoon floor was produced extending westward to the Yasawa islands. The Yasawa islands have been built up on this platform. It is thought probable that Mbengha also is a Post-Pleistocene volcano built on the ruins of an older one, which had been greatly eroded, then submerged and levelled by sedimentation and wave-cutting during a period when corals did not flourish.

The sub-mature topography of the island and the slight lateritization of its surface rocks show that the island is not very old. It appears to be of the same age as Munia and the more recent part of Kanathea.

The absence of signs of extensive submergence suggests that the younger Mbengha volcano, constituting the existing island, became active near the close of the Glacial epoch. Since that time the tropical climate has caused deep erosion, especially on the windward side.

Kandavu.

The group of islands of which Kandavu is the largest lies within the Great Astrolabe reef, some 40 miles south of Viti Levu. Kandavu is the southernmost of the group and extends for 15 to 18 miles in an east-west direction. A few miles off its northeastern shore is the circular island of Ono, some 4 miles in diameter. The other islands of the group are small ash and agglomerate remnants distributed over the northern part of the lagoon.

Kandavu is a long, rambling island separated into three nearly equal portions by constrictions. The isthmus connecting the central and western portions is so low that boats are dragged across by means of a tram-line.

Kandavu is built of andesitic flows and agglomerates of different ages. The eastern division of the island is sub-maturely eroded, but in the extreme west it includes a young volcano, Mbuke Levu, whose slopes are very slightly altered.

This topographic variety indicates a fairly complex history. No mention has hitherto been made of limestones in Kandavu, but the writer found a series of silicified rocks, charged with cavities, which have all the appearances of silicified limestones. These rocks outcrop at the head of a bay in the middle of the southern coast of the eastern segment of the island. Back of the little village of Kandavu, they form a series of cliffs, 100 feet in height, over which a stream cascades. The stream drains sub-mature hills of andesite in the interior. The silica introduced into the altered limestone was probably derived from the andesite which overlies the limestone. The limestones rest on an irregular surface of brecciated volcanic rocks, resembling rhyolitic tuffs but may possibly be a silicified andesitic ash. The accompanying cross-section, (Figure 40), shows the relations of the rock types. The limestones may have been formed in one of the periods of crustal quiescence which have interrupted volcanic activity in the island.

The coast of Kandavu gives immediate evidence of subsidence. It is the best example of an embayed shore-line known in Fiji. This is specially true in the south, where every little river emptying into the head or side of a bay shows a delta flat and flood plain. The same relations hold in Ono.

The John Wesley Bluffs at the northeastern side (northern coast) of the western segment of the island represent one of the striking features. The bluffs are nearly vertical and rise to a height of 150 to 200 feet. Since there is no barrier reef off the coast, it may be reasoned that the bluffs were formed by wave-cutting. However, the highest cliffs are those which do not receive the full force of the waves but rather are situated along a sheltered bay-side. If wave-action had cut back the coast at this point, there should be a sea-cut bench in front of the cliffs; yet near the cliffs the depths reach 107 fathoms, and, at their very base, the lagoon depths are 12 to 16 fathoms. Even if the cliffs were cut by the waves during the Glacial epoch, the waves, working at present sea-level since that period, should have cut a bench of considerable width. Such a bench does not exist.

The cliffs may, therefore, be due to a sub-recent wave-cutting, followed by recent subsidence; or they may be due to faulting. Hence the embayment of the local coast-line was not caused by the return of water to the ocean after the Glacial epoch but to actual subsidence. Such subsidence may be the more readily postulated in view of the general crustal instability in Fiji.

The presence of nearly a hundred feet of limestone at the eastern side of the island, overlying an irregular surface of volcanic rocks, leads to the inference that Kandavu was probably involved in the general subsidence affecting most of the islands of Fiji. The dismembered slopes of agglomerate and ash composing the numerous islands at the northern end of the Kandavu lagoon show that profound erosion has taken place within the island group. It may be that an older island once lay at the eastern end of the present lagoon of Kandavu, separated by a strait from another volcanic mass which now forms the small island of Solo within a separate lagoon. The deep erosion and subsidence of these volcanic islands allowed the present reefs to develop about them. Later extrusion then built up the western part of Kandavu.

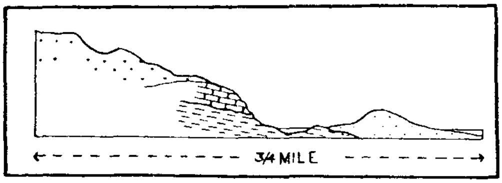


FIGURE 40. Cross-section of Elevated Limestones near the Village of Kandavu, Kandavu.
Blocked — elevated limestone. Dashed — silicified ash. Dotted — andesite.

In contrast to this view, it may be held that after the formation of the island in its present outline, a recent subsidence has tilted down its eastern portion and so formed the Great Astrolabe Reef. Lack of sufficient data makes impossible a connected outline of the development of Kandavu, but, in general, it has had a history not unlike that of the Exploring Group.

GENERAL REVIEW OF THE GEOLOGICAL HISTORY OF FIJI.

The various events in the geological history of Fiji, having been set down in tabular form in their appropriate places, need not be fully re-stated. A comparison of the tables will give the best general review of the history of the islands. There have been four periods of volcanism: a rhyolitic period, either contemporaneous with, or followed almost immediately by, an andesitic period; after a long interval, another andesitic period; and a recent period of basaltic eruptivity.

The relations of erosion, volcanism, and earth movements may be expressed briefly as follows: —

Batholithic intrusion, erosion, volcanism, brief erosion, subsidence, uplift, erosion, volcanism, subsidence, uplift, erosion, volcanism, submergence.

Little is known concerning the geological dates of these events. The fauna of the South Sea Islands has not been sufficiently correlated to fix the age, or ages, of the elevated limestones. Dall (1898, p. 168) states concerning the fossil mollusks, collected by Alexander Agassiz from the coastal-plain series, "None of the genera are extinct. The rock, however, looks decidedly too old for Pleistocene. I should say the fossils were younger than Eocene and might be either Miocene or Pliocene."

Skeats found in the upraised limestones of Mango a species of foraminifera, Orbitoides sumatrensis, which is similar to a Miocene form described by C. W. Andrews from Christmas Island, Indian Ocean, (Skeats, 1903, p. 120.)

Woolnough (1903, p. 464) states that the elevated reef near Suva "has yielded a considerable number of fossils of various kinds, the assemblage of which appears to indicate that the bed is not newer than Pliocene. Conspicuous among these fossils is a tooth of a large Carcharodon."

In contradiction to this, Brady (1888, pp. 1–10) finds that the marls associated with the coralliferous limestones of Suva are, without the "slightest hesitation," post-Tertiary. He states, "of the ninety-two species of Foraminifera which have been identified, eighty-seven are forms still living in the neighborhood of the Pacific Islands."

Dr. T. W. Vaughan of the United States Geological Survey kindly examined the corals collected by the writer from the Lau Group and from the elevated reef at Suva. He pronounced them Pleistocene or Recent, (See Table I).

TABLE I.

List of Fossils Collected, with Heights above Sea.

A. *Corals*,— Determined by Dr. T. W. Vaughan.
(Many of the species are figured in Pub. 213, Carnegie Institution of Washington.)

Acropora sp.?, South of Ndelai Yaloi, Kambara, (8 to 10 feet).
Dendrophyllia sp.?, Hill just east of the mouth of the Singatoka river, (60 to 70 feet).
Diploastrea heliopora (Lamarck), 3½ miles east of Na Sana Sana, S. W. Viti Levu, (15 to 20 feet).
Diploastrea heliopora (Lamarck), West of Nandi bay, S. E. Vanua Levu, (10 to 15 feet)
Favia stelligera (Dana), South of Ndelai Yaloi, Kambara, (8 to 10 feet).
Favia aff. F. speciosa (Dana), Navindamu, Fulanga, (10 feet).
Favia sp.?, Mana Islands, Ono-i-lau, (10 to 15 feet).
Favites abdita (Ellis and Solander)?, Nasangalau, Lakemba, (75 to 100 feet).
Favites abdita (Ellis and Solander)?, West of Nandi bay, S. E. Vanua Levu, (10 to 15 feet).
Fungia sp.?, Walu bay, Suva, Viti Levu, (30 to 50 feet).
Fungia sp.?, Mbuambua, West of the mouth of the Singatoka river, (15 to 20 feet).
Galaxea clavus (Dana)?, Navindamu, Fulanga, (75 to 100 feet).
Galaxea sp.?, Nasangalau, Lakemba, (75 to 100 feet).
Goniastrea sp.?, Ndelai Yaloi, Kambara, (8 to 10 feet).
Goniopora sp.?, Navindamu, Fulanga, (10 feet).
Hydnophora cf. H. exesa (Pallas)?, Dalithoni, Vanua Mbalavu, (10 to 15 feet).
Leptastrea bottae (M. Edw. & H.), Dalithoni, Vanua Mbalavu, (10 to 15 feet).
Leptoria tenuis (Dana)?, Yanuia Islands, Ono-i-lau, (10 feet).
Leptoria gracilis (Dana), West of Nandi bay, S. E. Vanua Levu, (10 feet).
Maeandra aff. M. lamellina (Ehrenberg), Yanuia islands, Ono-i-lau, (10 to 15 feet).
Maeandra(Coeloria) sp.?, Mbuambua, west of the mouth of the Singatoka River, (15 to 20 feet).
Maeandra sp.?, Nasangalau, Lakemba, (75 to 100 feet).
Montipora sp.?, Dalithoni, Vanua Mbalavu, (10 to 15 feet).
Orbicella sp.?, South of Ndelai Yaloi, Kambara, (8 to 10 feet).
Pocillopora grandis (Dana)?, Nasangalau, Lakemba, (75 to 100 feet).
Porites sp.?, South of Ndelai Yaloi, Kambara, (10 to 15 feet).
Porites sp.?, Mana islands, Ono-i-lau, (10 to 15 feet).
Symphyllia nobilis (Dana)?, South of Ndelai Yaloi, Kambara, (10 to 15 feet).
Stylophora pistillata (Esper)?, Nasangalau, Lakemba, (10 to 15 feet).
Stylophora sp.?, South of Ndelai Yaloi, Kambara, (10 to 15 feet).

B. *Mollusca*,— Determined by Dr. Paul Bartsch.

Cardium sp.?, Walu bay, Suva, Viti Levu, (30 to 50 feet).
Cypraea sp.? Walu bay, Suva, Viti Levu, (24 feet).
Lithophagus sp.?, Walu bay, Suva, Viti Levu, (25 feet).
Lithophagus sp.?, Na Sana Sana, S. W. Viti Levu, (10 to 15 feet).
Lucina sp.?, Mbuambua, West of the mouth of the Singatoka river, (10 to 15 feet).
Pecten sp.?, Na Sana Sana, S. W. Viti Levu, (10 to 15 feet).
Pecten sp.?, Mbuambua, Singatoka district, (10 to 15 feet).
Tapes sp.?, Na Sana Sana, S. W. Viti Levu, (10 to 15 feet).
Trochus sp.?, Na Sana Sana, S. W. Viti Levu, (10 to 15 feet).
Trochus sp.?, Mbuambua, S. W. Viti Levu, (10 to 15 feet).
Trochus sp.?, Walu bay, Suva, Viti Levu, (25 feet).
Turritella sp.?, Na Sana Sana, S. W. Viti Levu, (10 to 15 feet).
Venus sp.?, Na Sana Sana, S. W. Viti Levu, (10 to 15 feet).
Venus sp.?, Mbuambua, S. W. Viti Levu, (10 to 15 feet).
Venus sp.?, Walu bay, Suva, Viti Levu, (25 feet).

C. *Pisces*.

Diodon sp.?, Walu bay, Suva, Viti Levu, (25 feet).
(A new species now being studied by Dr. C. R. Eastman.)

The rocks of the coastal-plain series, of which the Suva limestone forms a part, appear to be decidedly younger than the limestones of the interior. Evidence in favor of this view is as follows:—

(1). Boulders of the older limestones occur in the basal conglomerate of the coastal series near Na Roro, 5 miles from the mouth of the Singatoka River.

(2). The interior marls are highly folded, in contrast to the low-dipping coastal series.

(3). The coastal series are much less recrystallized than the interior marls.

Woolnough (1907) has indicated on his maps of Vitu Levu only one series of marls and has placed this series in the Middle Tertiary. The writer early came to the conclusion that there were two series of rocks. Later he found that the order of events in Vitu Levu closely correspond to the order as made out by Mawson (1905, pp. 471–472) in the adjacent islands of the New Hebrides. These events may be tabulated as follows:

(1). "— local shallow marine conditions and subdued volcanic activity.

(2). "— development during Miocene times of a fold-ridge." "The folding force would appear to have been exerted from the direction of Fiji, against the foreland of New Zealand crystalline schists and gneisses.

(3). "— subsidence of outer wing (of fold) followed by extensive late Miocene andesitic eruption along the plane of weakness."

(4). "— faulting of the inner wing of the fold along the line of the present active volcanoes, letting down the sea floor to the east, thus putting fairly deep water between the New Hebrides and the Fiji land-surface.

(5). "— During all this period of volcanic activity, extensive submarine tuffaceous beds were accumulating above the folded Miocene series; the earlier deposits followed later by varieties of soapstone. No interbedded coral limestone was met among these tuffs." "Capping this series, are the raised coral reefs elevated to heights of over 2000 feet. The oldest of these is referable to a period not earlier than late Pliocene and probably not much later as it has since been intruded by lava from centers now extinct."

(6). "— The elevatory movements evidenced in these raised reefs is of a see-saw type, greatest in the west and least (probably in many cases a minus quantity) in the east, where

(7). "— the great recent basic eruptions have taken place."

Mawson regards "the elevatory tendency" as a "continuance of the tectonic movements so critically developed in Miocene times," but considers certain of the uplifts as the direct outcome of volcanic intrusion.

It is believed, therefore, that the older folded series of central Viti Levu are the equivalents of Mawson's Miocene folded series of the New Hebrides. The formation of the coastal-plain series of Viti Levu would then be referred to late Pliocene or Pleistocene time. The elevated limestones of the Lau and Yasawa Groups are correlated, from fossil evidence, with the coastal-plain series. The submarine tuff beds of the New Hebrides, as described by Mawson, are very similar to the rocks of central Vanua Levu. The lack of folding in central Vanua Levu probably means that these tuffs are essentially of the same age as the elevated limestones of the Lau Group and late Pleistocene instead of contemporaneous with the Miocene folded beds of Viti Levu.

As Mawson has stated for the New Hebrides, the elevatory movements of the coastal series in Fiji have been of a see-saw type and have continued to very recent times. The series is believed to be essentially conformable throughout, though the uplift of the islands of the Lau Group has continued through a period from late-Pliocene to Recent. Thus the coastal limestones near the mouth of the Síngatoka River may be more recent in date of uplift than the Rewa marls, but they belong essentially to the same series.

The ages of the plutonic rocks of central Viti Levu and of the sediments which they intrude can only be conjectured. The erosion which exposed these rocks was completed before the Miocene depression. They are doubtless at least as old as the early Tertiary.

BEARING OF THE RESULTS OF THE EXPEDITION ON THE CORAL REEF PROBLEM.

The several theories to account for barrier reefs and atolls are summarized, following Davis (1914) in part, by the outline given below.

- I. Theories which do not involve a positive shift of the sea-level.
    - A. Atolls built on submerged craters.
    - B. Atolls formed by upward growth on still-standing banks.
        - 1. The banks are graded to the proper level for coral growth by the waste from plankton. (Murray, 1880)
        - 2. The banks are formed by rapid wave action leveling the scoriatous waste of submarine volcanoes. (Wharton, 1897)
    - C. Barrier reefs and atolls formed by progressive outward growth of a fringing reef and the solution of an inner lagoon by ocean water. (Murray, 1880)
    - D. Veneering reefs on sea-cut platforms.
        - 1. Platforms are cut about high, volcanic islands which are later reduced to sea-level by subaerial erosion. (Tyerman and Bennet, 1832)
        - 2. Platforms are cut about elevated masses of coralliferous limestone. (A. Agassiz, 1899)
- II. Theories involving a positive shift of the ocean level.
    - A. Atolls and barrier reefs built on subsiding islands. (Darwin, 1842)
    - B. Atolls and barrier reefs built on platforms cut by Pleistocene wave-action and later submerged by the return of Glacial waters to the ocean. (Daly, 1915)

Murray's theory involving solution by ocean water has been discarded by most geologists, because of its quantitative inadequacy. Many writers believe that the banks are antecedent to the veneering reefs since they have greater extent than the reefs (Vaughan, 1914, p. 32), but do not attempt to explain the origin of the bank. In the next few pages the facts gathered in Fiji will be discussed in the light of the above theories.

While the earliest facts known concerning the two large islands of Viti Levu and Vanua Levu show that they were continental land masses, they were later submerged and covered by volcanic débris. Vanua Levu is composed in large part of submarine volcanic rocks.

The later history of the island has been characterized by uplift during Pleistocene and Recent times. Indeed, the Fiji group as a whole cannot be included in Darwin's or Dana's typical areas of progressive subsidence. The upward movement in southeastern Vanua Levu has continued into so recent times that near Vunelangi a lagoon flat and outer reef are preserved in all their details though elevated 50 to 75 feet above the present sea-level.

No remnants of coralliferous limestone occur near the summit or along the upper flanks of the ridges of Vanua Levu. This may best be explained by the very rapid erosion of the underlying weak deposits of volcanic dust, ash, and submarine tuff. The delta flats formed from this débris which should surround the island are lacking for the most part, though near Vunelangi remnants of a bench of such volcanic waste are found. It is apparent that after uplift the fine clays are soon shifted to the new level. Yet even then they should form delta flats near the present sea-level as they do near Vunelangi. That similar extensive flats do not exist is proof that the recent uplift in southeastern Vanua Levu is replaced throughout the other and greater part of the island by contemporaneous subsidence.

Previous conditions in Vanua Levu have been obscured by erosion and subsidence. Where uplifted reefs occur they have been elevated only one or two hundred feet. They rest on old land surfaces, indicating subsidence. The recent positive shift of the ocean level cannot be identified with the rise of the waters at the close of the Glacial period. It is much too recent.

From the earlier discussion of Viti Levu and from what has been said of Vanua Levu it is apparent that the larger islands of Fiji have had a very complicated history, and that it is futile to attempt to find any one theory which explains the present position of their reefs.

Conditions in the Lau islands are not so involved. Their elevated limestones are spoken of by Alexander Agassiz (1898) as Tertiary but the writer considers them Pleistocene or Recent. Two distinct problems are presented. The older elevated limestones represent one cycle of events; the modern reefs represent another.

With regard to the first cycle, Agassiz (1899) has stated, "Granting even, as is very probable, that when these Tertiary limestones were formed they were formed in great part by subsidence, and in part by accretion from the carcasses of the invertebrates living upon their surface, this would in no way help us to a satisfactory explanation of the formation of atolls and of barrier reefs by the growth of the corals of the present epoch." "The only evidence we have of the great thickness of coral reefs, such as is required by the Darwinian theory of the formation of atolls and of barrier reefs, is based upon the great thickness of the so-called elevated reefs observed in the Pacific by Dana, Darwin, and others.....That the latter are true coral reefs is more than doubtful. Those rocks are probably great masses of limestone similar to the so-called elevated reefs of the West Indies and the Pacific."

The mere fact of the deposition of limestone on a subsiding basement does not, in accordance with this statement, establish the truth of Darwin's theory. The elevated masses must be proven to be of coral origin, to have the reef form, and to rest unconformably on a volcanic substructure.

Several observers have considered the raised rims of such islands as proof of their atoll origin. The writer agrees with Agassiz that such evidence is not always conclusive, since atmospheric solution may lower the surface at the center of an elevated limestone bank faster than the surface at its edge, as instanced by the Florida plateau. Yet, even if this fact is established, one may well question that differential solution is competent to explain the great relative heights of the rims in Kambara and Wangava, which respectively average 260 and 300 feet higher than the central depression. If these depressions are due entirely to solution, it would appear that the underground channels, which conduct the drainage of the islands to the sea, ought long ago to have breached the surrounding rims.

Again, if these islands are truly raised atolls it may be held that reef limestones should characterize their rims while coral débris and other fine-grained material should dominate in the lagoon deposits. With this point in mind a study was made of the outer edges of the islands. Coral heads were often found in place, but in no greater abundance than within the lagoon deposits. Moreover, they were of the rounded type and not the fungus-shaped forms that occur at the edges of the present, growing reefs. The writer could not find a locality which might definitely be called the edge of an old atoll.

However, the atoll hypothesis need not be abandoned. The study of a growing reef shows that the characteristic forms of a reef-edge are lost a few feet behind that edge. The ocean waters, pressing through the over-hanging, porous edge, are continually destroying the coral heads and throwing their fragments on to the reef-flat. Often blocks of limestone, weighing several tons, are torn from the edge and cast on to the flat. It appears that the growing reef is only a thin veneer covering a mass of débris. If this conception is true, all evidence of a former barrier reef or atoll would soon be destroyed after uplift, and it is unnecessary to assume a considerable benching of the atoll in order to expose the inner lagoon limestones. The writer believes there is more chance for the preservation of the rounded coral heads growing near the centers of lagoons, where wave-work is less vigorous, than for the preservation of the reef coral at the edge of an atoll.

In spite of the lack of conclusive evidence the writer is inclined to believe that such islands as Kambara and Fulanga are elevated atolls. Further grounds for this belief are as follows: —

1) It is impossible to believe that the coralliferous limestones merely veneer older, non-coralliferous limestones, since the latter are nowhere exposed in spite of profound erosion.

2) The fossil corals occurring in the elevated limestones are identical with living species which are now constructing atoll-reefs.

3) The atoll form of the islands is too strongly marked to be merely the result of differential solution.

4) The normal limestone-coral banks of the present day are higher at their center than at their edges and hence, if they were elevated, would not have interior depressions.

Ancient atolls are therefore preserved in the uplifted limestone islands of Fiji; likewise an ancient barrier reef is recognized in the elevated reef of Lakemba. Most important of all is the fact that in all known cases the older limestones rest unconformably on an eroded basement.

Daly, however, (1915, pp. 199–200) infers that certain islands of Fiji which have the atoll-form were developed on Pleistocene wave-cut benches in post-Pleistocene time, and were subsequently elevated. Kambara and Fulanga belong in this class. Such a conception would divide the cycle of the older limestones into two parts and would negative the view that the elevated atolls developed as a result of the subsidence of their eroded basement. In the older division would be placed the limestones planed by Pleistocene wave-cutting; in the younger division the post-Pleistocene atoll-limestones would be found. Accepting this hypothesis, an unconformity should exist between the two limestone series. If such an atoll were elevated over 40 fathoms, the depth of a stable, Pleistocene, wave-cut bench below the present sea-level according to Daly, the unconformity should be exposed, if the outer reef-face were sufficiently eroded. The atoll of Fulanga has been elevated more than 45 fathoms, that of Kambara more than 60 fathoms; yet no evidence of an unconformity was seen in the retreating sea-cliffs of these islands.

Again, if Fulanga were elevated 45 fathoms, the Pleistocene bench, according to the hypothesis, should appear near sea-level and the present lagoon depth of 10 fathoms be explained most logically by recent subsidence. The depth of the Fulanga lagoon corresponds closely to the depths within adjacent modern reefs. Neither Fulanga nor Kambara have any indications of benches, either above or below sea-level, which may be interpreted as Pleistocene, wave-cut platforms.

If the Glacial-control theory is still adhered to, the atolls must be pre-Pleistocene in age, but Daly considers that atolls and barrier reefs originated specially in post-Pleistocene time and were perhaps rare forms in the pre-Glacial oceans. If these atolls were pre-Glacial, they would easily have been destroyed by Pleistocene wave-cutting.

There is no evidence that the cycle of the elevated limestones was broken by a period of Pleistocene wave-cutting. The writer believes therefore that, in the older cycle, barrier reefs and atolls originated by the subsidence of eroded, volcanic surfaces.

The present cycle was initiated by the uplift of the older limestones. During the cycle these limestones have been differentially elevated and their present state of erosion indicates that they were by no means elevated contemporaneously. Vatu Vara is 1030 feet high and remarkably well preserved. Vekai is but 12 feet high and represents the final residual mass of a former island destroyed by atmospheric solution. A close study of the charts leads to the conclusion that the less the erosion of an island, the less is the depth of its surrounding lagoon. This inference holds true in spite of the fact that by progressive erosion the lagoons should be filled and is explained by a recent subsidence.

All of the islands are being rapidly reduced to sea-level by atmospheric solution. Sea-level flats dotted by residual masses of limestone should be the ultimate stage of this process. Portions of Fulanga and Ongea present examples of this stage, but such examples are rare. Lagoons dotted by undercut islets, the submerged complements of such flats, are, however, very common. All the recently uplifted islands have no lagoons, or else shallow lagoons. All the eroded islands have lagoons indicating subsidence. Hence still-stand with the production of large solution flats near sea-level is very uncommon. The inference follows that uplift is soon followed by subsidence. In this way a new generation of atolls is developed on the eroded and submerged platforms of the older limestone masses.

Table II presents the facts concerning the size and maximum depth

TABLE II.

Dimensions of Reefs and Deepest Lagoon Soundings in the Lau Group.

(The elevations of limestone masses within the reefs are given immediately after names.)

	Width miles	*Length* miles	*Depth* fathoms		*Width* miles	*Length* miles	*Depth* fathoms
Wailangilala	2.7	4.	23	Reid Reef (60′)	6.	8.	21
Duff Reef	2.	6.67	11	North Argo Reef (80′)	5.3	10.6	26
Williamson Reef	1.	1.3	13	South Argo Reef	10.	24.	36
Dibble Reef	1.3	2.25	15	Lakemba (320′)	6.	13.3	14
Naitamba (610′)	3.3	4.	9	Aiwa (210′)	3.3	9.3	23
Kimbombo	2.6	5.3	11	Oneata (160′)	6.	11.3	20
Bell Reef	1.6	2.3	12	Olarua	1.6	2.3	7
Malima	2.3	2.3	11	Thakau Vuite	2.	3.3	16
Exploring Group	21.3	26.6	94	Komo	3.3	5.3	17
Kanathea (350′)	5.3	9.3	15	Mothe	3.5	10.6	8
Mango (630′)	4.	4.	2	Thakau Motu	3.	6.	24
Malevuvu Reef	2.	2.6	14	Namukai Lau	3.	6.7	13
Vekai	1.8	2.	17	Yangasa Group (390′)	6.	10.	17
Katafanga (180′)	2.6	4.	13	Thakau Levu	2.	5.	13
Tuvuthá (800′)	3.	4.3	9	Fulanga (260′)	4.6	6.	10
Thakau Tambu	2.6	3.3	11	Ongea (270′)	5.2	8.	13
Thakau Lasemarawa	2.	2.3	6	Ono Group (15′)	4.	6.7	6

of the barrier reefs and atolls of the Lau islands. Fifty per cent of the lagoons have maximum depths of between 60 and 90 feet. Wave-erosion is ineffective at such depths within a lagoon. Solution by ocean water is as inefficient a cause. Submergence is the only alternative, and, since the rise of the waters is more recent than the return of the waters after the Glacial period, an actual subsidence must have occurred.

It is apparent that the movements have been very irregular. They are confined to small segments of the earth's crust and are undoubtedly associated with volcanic activity. In part the movements have been due to the transfer of material from the inner to the outer portions of the earth's crust; and in part to the secular condensation of the extruded lavas and pyroclastics. (Cp. Gerland, 1895, p. 56, and Daly, 1915, p. 232).

Referring again to the theories of coral growth (p. 88), it is seen that none of them, taken by itself, is applicable to the Lau islands. None of the modern reefs appears to be growing on a submerged crater rim. In each observed case, a foraminiferal deposit occurring beneath elevated limestone rests on an eroded basement and gives no evidence of having assisted in aggrading a submerged, volcanic mass to the level of coral growth. Indeed, in only one instance, near Savu Savu bay, Vanua Levu, was an uplifted reef found which rested on a contemporaneous, submarine lava flow, and none was found resting on benches which appeared to have been cut by submarine erosion.

Only Darwin's theory postulates a subsiding basement eroded above sea-level. But this theory is firmly based on the conception of progressive, though intermittent, subsidence of large segments of the earth's crust. The elevated limestones of Fiji were deposited during pre-Recent subsidence. Since the Pleistocene period, the algebraic sum of the earth movements has been positive and uplift has resulted; although the sum, if reckoned from the early Tertiary, is negative and the ultimate result has been subsidence. However, the present reefs are dependent for their form upon Pleistocene and Recent movements. Hence it cannot be said that the modern reefs of Fiji fully support Darwin's theory, since their history is not expressed by the simple succession of fringing reef, barrier reef and atoll. The history of the older, elevated limestones more nearly coincides with Darwin's theory than does the history of the modern reefs.

SUMMARY OF THEORETICAL RESULTS.

The writer's views concerning the origin of barrier reefs and atolls may be summarized as follows:—

1. The present coral reefs have been developed on surfaces which have been formed, as Agassiz in principle held, by the integration of a number of processes acting during several geological periods. These processes are, (a) atmospheric erosion, (b) wave-cutting, (c) sedimentation, and (d) volcanic aggradation.

2. There is no logical reason why a coral atoll, given the proper submarine bench, should not have existed in pre-Glacial as well as in post-Glacial time.

3. It is demonstrated that the older coralliferous limestones of Fiji developed on a subsiding basement of eroded volcanic rocks and formed barrier reefs and atolls. Very few of the modern reefs have been formed in a similar way.

4. Certain atolls are now developing on basements of elevated

limestone which have been eroded to fairly even surfaces by atmospheric solution, and later submerged.

5. Areas of subsidence in Fiji have undoubtedly been compensated by areas of uplift. In the latter areas shoals or islands have been formed, on or about which coral reefs have developed.

6. In Fiji, the Darwinian order of fringing reef — barrier reef — atoll is not generally the result of progressive subsidence. On the other hand, the association of the three reef forms is due to a series of irregular movements during which platforms are developed by the integration of the above-mentioned processes.

7. The detailed history of the islands of Fiji shows that they have not been stable during recent geological time, and an adaptation of Darwin's theory may apply to many of these islands. Yet it is not safe to assume its universal application.

In conclusion, it may be stated that in Fiji as elsewhere (Cp. Vaughan, 1914, p. 31) the modern reefs are developing on basements which are antecedent to the reefs. Most of the older writers postulated that the reefs rested on wave-cut benches, without telling how such benches could be carved in spite of the protection of the reefs, or why the reefs should be absent. The Glacial-control theory solved the problem by assuming that the reefs were removed during the Glacial period. The data assembled by Daly (1915) and Vaughan (1916) convince the writer that Pleistocene benches exist very generally throughout the coral seas. Nevertheless, the platforms in Fiji are much more modern in their development. The writer was unable to discover in these islands any evidence of Pleistocene wave-cut platforms.

PART II.—PETROGRAPHY OF FIJI.

By Wilbur G. Foye.

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INTRODUCTION

The main object of the expedition to Fiji was the study of the geology of coral reefs. It was not possible therefore, in the allotted time, to collect a series of igneous rocks representative of the nature and distribution of the various types in the islands. Specimens were collected, for the most part, from localities near the seashore where they were associated with coral limestones.

It will be evident in the discussion of the petrology of the islands, that the solution of many important problems must await further investigation.

PREVIOUS WORK.

Many travellers have collected rocks in Fiji from time to time, but as few of these men were petrographers little has been written on the petrology of the islands. One of the most important contributions has been made by E. W. Skeats (1903). He added materially to the knowledge of dolomitization throughout the group, by publishing a long list of analyses of elevated limestones.

Dana, Kleinschmidt, Gräffe, Macdonald, Seeman, Horne, and Agassiz, all brought back extensive collections of rocks, but these rocks were described by other investigators. Woolnough, Andrews, Guppy, and Cochrane, alone have described their own specimens.

The first detailed petrographic work on rocks from Fiji was done by Arthur Wichmann, (1882). Wichmann described a series of rocks collected by Th. Kleinschmidt (1879) during an expedition to the islands in 1876–78. He also included in his paper, the description of a smaller collection, made by Gräffe (1869) in the years 1862 and 1865. The rock types determined were as follows: —

granite,
quartz porphyry,
syenite porphyry,
foyaite,
diorite,
diabase,
gabbro,
andesite,
basalt,
tuff,
amphibolite,
eurite,
quartzite.

Members of the Challenger Expedition, while anchored at the port of Kandavu, collected a few rocks. These were described by

A. Renard (1888) in the report of the Expedition. Only three types were noted:—

hornblende andesite,
augite andesite,
biotite andesite.

In 1899, Arthur S. Eakle (1899) described some of the igneous rocks, collected by Alexander Agassiz during his voyage among the islands. The types determined were:—

diorite-granite,
augite andesite,
augite-biotite andesite,
augite-olivine andesite,
hypersthene andesite,
hornblende andesite,
basalt,
olivine basalt.

E. C. Andrews (1900) visited the islands in 1898 and in a report on the "Limestones of the Fiji Islands" gave a brief description of the volcanic rocks which he collected.

In 1901, Walter G. Woolnough (1903) made a journey across Viti Levu, and, for the first time, found granites in place. He described the following rock types:—

granite,
quartz diorite,
diorite,
augite andesite,
pyroxene andesite,
hornblende andesite,
olivine andesite,
porphyritic basalt.

H. B. Guppy (1903), during his travels in Vanua Levu between 1896 and 1899, collected a large number of rocks which he carefully described in his book concerning the geology of this island.

N. D. Cochrane (1911), acting as Government Mining Adviser, described briefly a large number of rocks from the islands. The chief types noted were:—

I. Sedimentary Rocks.
  redistributed tuff,
  tuffaceous marl,
  limestone,
  marble.

II. Volcanic Rocks.
  tuff,
  basalt,
  dolerite,
  augite andesite,
  hornblende andesite,
  mica andesite,
  olivine andesite,
  hypersthene andesite,
  trachyte,
  porphyrite,
  gabbro,
  diabase,
  diorite,
  quartz diorite,
  hornblende granite,
  biotite granite.

SEDIMENTARY ROCKS.

The main types of sedimentary rocks collected during the present expedition were as follows: —

marl,
conglomerate,
limestone,
marble.

Red sandstones and shales were found in the beds of streams draining the central part of Viti Levu. Their source was not located. Other sandstones, composed of slightly river-worn volcanic materials, were commonly found interbedded with the boulder conglomerates which lie on the slopes of maturely-eroded andesites or form the basal layers of the coastal sediments of Viti Levu.

Marl. Two types of marl may be found in Fiji. The first type belongs to the folded series of central Viti Levu; the second, forms a part of the coastal-plains series.

The marl of central Viti Levu is brownish drab in color and has the usual even, fine-grained texture of these rocks. Rocks of this description occur to elevations of 2000 to 2500 feet and are often highly folded.

Under the microscope, the rock shows a paste of limonite, kaolin, and calcite, in which occur many minute, angular bits of quartz and feldspar. Only a few of the feldspars show albite-twinning but their indices of refraction correspond to plagioclase. The twinned varieties have a composition approximating oligoclase or acid andesine.

The nature of the clastic material found in these rocks would indicate that they were eroded from the granites or diorites of the interior. At the southeastern side of Viti Levu, near Suva, a conglomerate, underlying flows of andesite and basalt, includes boulders of quartz porphyry and diorite. It is believed the two deposits represent a long period of erosion, in which the plutonic rocks of the center of the island were laid bare.

The marl from the coastal-plain series bears the popular name, "soapstone." It has a slate-gray color and becomes very smooth and oily when wet. Near Suva, lenses of coralliferous limestone are interbedded with this rock. When dry, the marl has little cohesion and breaks down readily. On exposure the ferrous oxide becomes oxidized and the rock assumes a yellowish brown color. It is rich in foraminifera and sometimes carries plant remains such as seed pods. Brady (1888) records that some of the foraminifera found by him in the marl, near Suva, were dredged by the "Challenger" in depths not less than 150 fathoms.

In 1907, specimens of the rock were sent to the Imperial Institute for examination. The specimens were labelled as follows:—

"A. Soapstone, Fiji. Surface, Government Office Yard."

"B. Soapstone, 6 feet below the surface, Suva."

Wright (1916) quotes the following description as given by the Imperial Institute.

"The two samples are similar in appearance and character. They were not soapstones, but may be classed as marls. They consist of volcanic dust, containing feldspar, hornblende, magnetite, and mica, together with a considerable quantity of the remains of calcareous and silicious organisms; some unbroken foraminifera occurred in both samples."

"Chemical examination of the samples gave the following results:—

	A	B
SiO_2	30.41	38.56
Al_2O_3	12.08	16.49
Fe_2O_3	5.40	7.54
MgO	6.95	5.78
CaO	19.24	12.77
K_2O	1.23	1.64
Na_2O	1.23	2.72
P_2O_5	trace	trace
NiO	trace	trace
H_2O+CO_2 (loss on ignition)	23.28	14.32
	99.82	99.82

It has previously been stated that the marls, near Suva, were probably laid down as a former delta-flat of the Rewa River. Their composition indicates that the river redistributed a large amount of ash and pumice, emitted by the coast volcanoes. The main mass of this rock, however, consists of silt, swept from the lateritized hills of the interior and deposited with calcium carbonate in the delta-area.

Conglomerate. Two varieties of conglomerate may be distinguished in Fiji. The one is a river-conglomerate and is poorly consolidated or has a small amount of siliceous cement. The other has a large amount of calcium carbonate associated with it, in the form of shells, corals, and cement. It was originally deposited along old shore-lines but now may often be found far inland. The first variety is not known in the smaller islands.

The river-conglomerates are often very coarse and contain boulders of andesite, basalt, and limestone 2 or 3 feet in diameter. Such deposits are well seen at the Na Roro bluffs 5 or 6 miles from the mouth of the Singatoka river, and are quarried for road-metal, a few miles up the Tamavua river, near Suva. They occur about the bases of eroded hills of basalt and andesite and, near Suva, are overlain by marls which contain occasional, larger boulders. Interbedded with the coarser conglomerates are layers composed of sand and gravels which have been washed from near-by agglomerates and are but slightly water-worn.

Two varieties of river-conglomerate are known. The first has pebbles and boulders of quartz-porphyry and diorite. It is found 2 or 3 miles from the mouth of the Visari river, at the western side of Suva harbor. It is overlain by lava flows of the second andesitic period and hence belongs to the period of erosion in which the folded sediments of central Viti Levu were deposited. Many of the pebbles in the conglomerate are sheared and it undoubtedly underwent the same folding which disturbed the marls of the interior.

The second variety of river-conglomerate consists predominantly of andesite and basalt débris and appears to have been eroded from the directly underlying agglomerates or flows. The matrix is often a reddish gray paste which resembles a redistributed ash. The Na Roro and Tamavua conglomerates belong in this class. The Na Roro deposit has pebbles and boulders of limestone, eroded from the limestones of the interior. The pebbles are usually much silicified. This type of conglomerate is often associated with a calcareous conglomerate, lying nearer the present shore-line and forming the basal member of the coastal-plain sediment.

Calcareous conglomerates unconformably overlie volcanic rocks in many of the islands. They are the basal members of the folded interior sediments, found 40 miles from the mouth of the Singatoka river, near Wai Mbasanga, and also of the coastal-plain series, exposed all along the southwestern coast of Viti Levu beneath the marls. Pebbles of volcanic rocks seldom form over 50 per cent of these deposits. Shell and coral waste with a calcareous cement compose the greater part of rock and, in thin sections, numerous foraminifera may be seen. By losing their coarser shell and coral material, these rocks grade upward into marls.

Limestones and Marbles. It is believed that all the limestones of Fiji are coralliferous. Some writers have spoken of the limestones of central Viti Levu and Vanua Mbalavu as massive and have inferred that they were formed by other agencies. Many of the interior limestones are so recrystallized that their structure is almost lost, and folding has transformed some of the limestone members to marble. But the writer found corals associated with the basal layers of this series and Mr. C. A. Holmes of the Lands Department, Suva, states that corals occur in the limestones of the inland valleys near the head of the Navua River.

The colors of the limestones are prevailingly cream-white, pink, and brick-red. An exceptional silver-gray limestone (weathering to a cream tint) was found near Lambasa, on the northern coast of Vanua Levu. Its color is the more remarkable since it is a very pure limestone and is burned for lime by the Colonial Sugar Refining Company.

Two partial analyses of the rock, supplied through the kindness of Manager Berry, are as follows: —

	Best	*Worst*
Insol	2.18	19.63
Sol. SiO_2	.46	
Al + Fe	1.37	5.54
CaO	52.96	37.68
MgO	.89	1.27
CO_2	41.20	29.60
H_2O	.58	4.46
Organic	.36	1.82
	100.00	100.00

The residual, hoodoo peaks of limestone which dot the landscape in certain parts of Fiji are composed of a cream-white or pink lime stone. At the surface this is cavernous but in depth most of these cavities are filled with crystalline calcite, not yet dissolved out. Even the pink varieties have only a slight amount of iron oxide which gives them their color, as shown by the analyses of Skeats (1903, p. 124). It is important here to note that selective solution probably accounts for the high content of magnesia in these residual peaks. Skeats found "the occurrence of dolomite at the summits of many of the islands. . . . significant."

The pink and brick-red colors are closely related and are due to the oxidation of the marl and volcanic waste deposited as a fine sediment about the coral heads. If the rocks are especially compact and do not permit the free circulation of aerated waters, the gray colors of the marl may be preserved. Examples of this were found at Lambasa.

The depth of the residual, brick-red soil which overlies the limestone is important as an indication of the amount of limestone lost by solution. For example, the depth of soil-cover at the summit of the limestone plateau of northern Vanua Mbalavu averages 2 to 3 feet. The average analyses of 17 limestones from the same locality show less than one tenth of one per cent of insoluble matter, (Skeats, 1903, p. 75). It follows that the amount of limestone lost by solution must be reckoned in hundreds of feet.

IGNEOUS ROCKS.

The following descriptions of the main igneous types refer to the various islands in the order: Viti Levu, Mbengha, Yasawa group, Vanua Levu, Taviuni, Lau Islands, and Kandavu. The petrologic problems involved will be briefly treated later.

It should be noted that in this paper the word "basalt" refers to a rock composed chiefly of augite and basic, plagioclase feldspar.

I. Rocks from Viti Levu.

1) *Tonalite.* Tonalite outcrops at Vunatoto, as low, rounded hills along the course of a branch of the Singatoka river, leading south from the village of Wai Mbasanga, central Viti Levu.

The rock is a holocrystalline, light, bluish-gray diorite of medium, coarse grain. It consists largely of feldspars 8 to 10 mm. long and 6 to 7 mm. wide, among which are disseminated irregular bits of quartz, hornblende, and biotite. A Rosiwal measurement gave the following proportions by weight:

Quartz	20.42	per cent
Plagioclase	73.44	" "
Magnetite	2.02	" "
Biotite	1.28	" "
Hornblende	2.84	" "
	100.00	" "

Pebbles in the conglomerate near Suva harbor are essentially similar, though richer in quartz.

The *quartz* has a wavy extinction due to strain and is often quite brecciated.

The *feldspars* are zoned and give evidence of intermittent growth. Their composition ranges from basic oligoclase to acid andesine or from $Ab_{78}An_{22}$ to $Ab_{63}An_{37}$. No orthoclase was found in the rock.

The *biotite* is chestnut brown in color.

The *hornblende* is a common variety, pleochroic, colorless // X, faint yellow // Y, and greenish yellow // Z.

The rock is very slightly altered and has a hypidiomorphic, granular structure. Its order of crystallization is: —

magnetite,
biotite,
hornblende,
plagioclase,
quartz.

The chemical composition of the rock approaches that of a granite, and undoubtedly granites are associated with it in the field; but the dominance of andesine and the absence of orthoclase, lead the writer to designate it as tonalite.

Chemical analysis gave:—

SiO_2	70.00
TiO_2	0.30
Al_2O_3	14.72
Fe_2O_3	1.36
FeO	2.28
MnO	0.04
MgO	1.37
CaO	3.58
Na_2O	3.70
K_2O	1.68
H_2O	0.50
P_2O_5	0.06
	99.59

Norm	
Quartz	31.38
Orthoclase	10.01
Albite	31.44
Anorthite	16.96
Corundum	.51
Hypersthene	6.04
Magnetite	2.09
Ilmenite	.61
Apatite	.31
Water	0.50
	99.85

Specific gravity at 20°C = 2.675

Its position in the norm classification is, therefore:—

Class I	Persalane
Order 4	Britannare
Rang 3	Coloradase
Subrang 4	Yellowstonose.

Of the rocks classified by Washington (1903, pg. 191) under this system, a quartz-diorite from Aruba Island, West Indies is most closely allied to the Fiji type.

2). *Dioritic Gabbro.* Immediately back of the village of Waimbasanga low, rounded hills of gabbro rise to heights of 75 to 100 feet above the level of the Singatoka river. The relation of the gabbro to the granite is not exactly known. As one passes further south the gabbro disappears and diorites and granites outcrop. The textural similarity of these rocks leads to the belief that they are transitional into one another.

A Rosiwal measurement of the rock gave the following result.

Labradorite	62.85	per cent
Amphibole	27.90	" "
Magnetite	9.01	" "
Titanite	.24	" "
	100.00	" "

The feldspar shows pericline and albite twinning. It is zoned and has a composition varying from $Ab_{50}An_{50}$ to $Ab_{40}An_{60}$.

The amphibole is uralitic, probably derived from pyroxene, though none of the latter mineral remains. It is sometimes in crystals of considerable size but more often forms a felted mass of minute shreds.

The rock is very fresh in appearance and has a hypidiomorphic, granular structure. Its order of crystallization was probably as follows:—

titanite,
magnetite,
augite,
feldspar,
amphibole.

3). *Aporhyolite or Quartz porphyry.* Aporhyolites were not found in place in Viti Levu. The rocks to be described occur as pebbles and boulders in the conglomerate described from the Visari river, near Suva.

Three varieties are known. They are very dissimilar in appearance, due to recrystallization and crushing.

Variety 1, a glassy, slate-black type, is the freshest of these rocks. Grains of quartz and feldspar occur in a glassy, somewhat spherulitic ground-mass. The quartz phenocrysts occur as amoeboid, resorption forms. The feldspar phenocrysts are slightly zoned and average oligoclase in composition.

Variety 2 of a light gray color has similar phenocrysts, but its ground-mass is entirely recrystallized. The spherulitic forms are sometimes discernible but often the quartz fibers have enlarged themselves, forming distinct crystals. There is also a semblance of myrmekitic structure as reaction rims about the large quartz phenocrysts.

Biotite is found in scattered bits through the rock.

Variety 3, a light yellowish-gray rock, has undergone a considerable amount of shattering due to pressure. It is practically the same as variety 2. Its yellowish tint is due to a large amount of epidote scattered through, and veining, the ground-mass. The spherulitic structure is still preserved.

4). *Feldspar Porphyrite.* The rock to be described occurs as flows overlying the gabbro back of Waimbasanga, Singatoka river. It represents the first period of andesitic activity in Viti Levu.

The porphyrite is dark, slate gray in color, holocrystalline, and very fine-grained. Only occasional small phenocrysts of feldspar (2 to 3 mm. in diameter) are visible. They are indistinct, since they have the same color as the ground-mass. The rock appears fresh in the hand specimen but under the microscope is seen to be much recrystallized and metamorphosed. Considerable deposits of chalcopyrite are associated with the rock.

Augite may have formed a part of this rock at one time but no trace of it is now present. Actinolite is found in felt-like masses throughout the rock and occurs as needles in the feldspar, clouding the crystals.

The ground-mass of the rock is a complex of fibrous actinolite with laths of labradorite, Ab_{50} An_{50}, and grains of epidote and magnetite.

5) *Olivine Basalt from the Tamavua River.* Basaltic boulders occur in the conglomerate which forms the basal member of the coastal-plain series along the Tamavua river, near Suva. As basalts cut this series farther west, it is considered that the rock here described belongs to an earlier date than the last basaltic eruption and is probably contemporaneous with the second andesitic period.

The basalt is greenish black in color, compact, and recalls a porphyritic diabase.

The phenocrysts are olivine and labradorite, $Ab_{40}An_{60}$, with a few augites. Augite, labradorite, magnetite, and secondary minerals compose the ground-mass, which has an ophitic structure.

6) *Olivine Basalt from Lautoka.* Masses of greenish-black olivine basalt occur as residual boulders on the late-mature hills about Lautoka, on the western side of Viti Levu.

The rock is holocrystalline and very fine-grained. The phenocrysts in the rock consist of stubby, euhedral augite (4 to 5 mm. long) and rounded grains of zoned plagioclase, $Ab_{25}An_{75}$ to Ab_7An_{93}, (2 to 3 mm. long) with many olivine crystals.

The ophitic ground-mass is composed of olivine, augite, feldspar and abundant minute flecks of magnetite. Serpentine is secondary after the olivine.

The following analysis shows that the basalt is quite basic in composition.

SiO_2	47.36
TiO_2	0.85
Al_2O_3	19.38
Fe_2O_3	3.60
FeO	6.13
MnO	0.11
MgO	5.31
CaO	10.54
Na_2O	2.69
K_2O	1.74
H_2O	2.20
P_2O_5	0.19
	100.10

Norm	
Orthoclase	10.01
Albite	20.96
Nephelite	1.14
Anorthite	35.58
Diopside	12.82
Olivine	9.76
Magnetite	5.34
Ilmenite	1.67
Apatite	.31
	97.59
Water	2.20
	99.79

Specific gravity at 20°C = 2.855

Its position in the norm classification is: —

Class II	Dosalane
Order 5	Germanare
Rang 3	Andase
Subrang 4	Andose

7) *Olivine Basalt from Na Sana Sana.* The basalt, here described, occurs as a dike, 10 to 15 feet in width, in the elevated coralliferous limestone near Na Sana Sana, southwestern coast of Viti Levu.

The rock is greenish black in color, holocrystalline and somewhat vesicular. Calcite fills the vesicles. The phenocrysts of augite are in minute needles, while the feldspars ($Ab_{40}Au_{60}$) are in laths 4 to 6 mm. in length.

There are many irregular areas which appear to represent decomposed olivine. Chlorite, serpentine, epidote, and quartz are secondary constituents of the ophitic ground-mass. The alteration has been hastened by the action of sea-water.

The rock has inclusions of limestone. Near these inclusions there is a large amount of epidote and chlorite. The feldspar associated with the contact is more acid andesine, approaching oligoclase.

II. Rocks from Mbengha.

A considerable collection of rocks was made both from the sea-coast and from the hills of Mbengha. Eight of them were studied and it was found that they were all basalts. They fall into three groups. A typical specimen from each group will be described.

1. *Basalts composed chiefly of Augite and Feldspar.* It has been stated in the section giving the descriptive geology of Mbengha that the western side of the island is composed of flows which are little dissected. These flows are characterized by their lack of olivine. Specimens were collected from Ravi Ravi, from west of Wai Somo and from the top of the highest hill, the Beacon. Another specimen came from a dike cutting an olivine basalt at the southeastern side of the island, Ndakuni.

These rocks vary in appearance accordingly as they are holocrystalline or vitrophyric. The vitrophyric varieties are dark gray to black in color while the holocrystalline, diabasic varieties are greenish black.

One of the vitrophyric varieties has augite (diallage) and feldspar phenocrysts, in crystals 5 × 3 mm. in size, abundantly scattered through a glassy paste. Another is vesicular and the phenocrysts are so minute in size that they are indistinct in the slate-gray ground-mass.

The holocrystalline variety is very fine-grained, with minute needles of feldspar showing fluidal arrangement about an occasional augite phenocryst, 3 to 4 mm. in diameter.

The feldspar is almost always zoned and varies from acid to basic labradorite ($Ab_{50}An_{50}$ to $Ab_{25}An_{75}$). The feldspar of the ground-mass is usually a medium labradorite ($Ab_{40}An_{60}$).

2. *Basalts composed chiefly of Augite and Feldspar with Olivine.* The basalts characterized by olivine were collected from the south-eastern or deeply dissected side of Mbengha, at Ndakuni and Ndakuimbengha.

They are very similar in general appearance to the types just described; though a glassy ground-mass appears in only one specimen. The typical rock is greenish black in color, compact and porphyritic in structure. The euhedral olivine phenocrysts are 8 to 10 mm. in diameter. The augite phenocrysts, in cases corroded, are about the same size or smaller. Zoned labradorite, ($Ab_{45}An_{55}$ to $Ab_{30}An_{70}$) is present but is often indistinct in the hand specimen. The ground-mass is usually ophitic.

3. *Basalt composed of Augite and Feldspar with Hornblende.* Somewhat east of the center of the southern coast of Mbengha, a considerable bay indents the island. The town of Natheva lies at the head of the bay. Near its center and around its sides there outcrops a porphyritic hornblende basalt. The hornblende phenocrysts are largest (8 to 12 mm. long) at the east side of the bay and decrease in size to the west. The other phenocrysts are euhedral augite and labradorite, $Ab_{40}An_{60}$. The augite occurs in sharply euhedral crystals, showing the forms (001), (010), (100) and (011). The crystals are elongated parallel to c. The hornblende is a basaltic variety, pleochroic, chestnut-brown to yellow. The crystals are surrounded bq an opaque rim of magnetite with some augite.[2]

III. ROCKS FROM THE YASAWA GROUP.

Very few of the Yasawa Islands were visited. Volcanic rocks were collected from but two islands, Nathula and Arawa, a small island just west of Yasawa-i-lau.

Nathula yields only basalts of quite uniform composition. Arawa is composed of agglomerates. All the regular boulders from the agglomerate appear to be very similar. The specimen collected was a hornblende andesite.

1. *Basalt.* The specimen was collected from a flow interbedded with agglomerates near sea-level at the southwestern corner of Nathula.

The rock is greenish black in color, holocrystalline and porphyritic.

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[2] Cp. Guppy, 1903, p. 306.

The phenocrysts of augite and zoned labradorite, $Ab_{42}An_{58}$ to $Ab_{26}An_{74}$, are small and about equal in size (2 to 3 mm. in diameter). The ground-mass forms about 80 percent of the rock which is fresh and above the average in weight. A few small vesicles are present. The ground-mass is ophitic; it bears magnetite and a little serpentine.

The chemical composition is:

SiO_2	50.06
Al_2O_3	19.38
Fe_2O_3	1.83
FeO	5.54
MgO	6.53
MnO	0.47
CaO	12.06
Na_2O	1.16
K_2O	0.93
H_2O (below 100°C)	1.14
H_2O (above 100°C)	0.37
CO_2	0.31
Total	99.78

Specific Gravity at 20°C = 2.808
Analyst, L. F. Hamilton.

Norm	
Quartz	2.88
Orthoclase	5.56
Albite	9.96
Anorthite	44.76
Diopside	12.36
Hypersthene	19.60
Magnetite	2.55
	97.67
Water	1.51
CO_2	0.31
Total	99.49

Its position in the norm classification is:—

Class III	Dosalane,
Order 5	Germanare,
Rang 4	Hessase,
Subrang 3	Sodipotassic (unnamed).

Washington, in Professional Papers, Nos. 14 and 28, of the U. S. Geological Survey, reports no basalts having analyses similar to the above.

2. *Hornblende Andesite.* The andesite was found as a boulder in an agglomerate interbedded with ash on Arawa Island, just west of Yasawa-i-lau. This island has an area of but little over an acre.

The rock is light gray in color, with a brownish tinge due to weathering. It has phenocrysts of hornblende in lath-like forms, 4 to 5 mm. long. The zoned phenocrysts of andesine (Ab_{72} An_{28} to Ab_{60} An_{40}) are 3 to 4 mm. long and 2 mm. wide. The partly glassy ground mass is greenish gray in color; its feldspar is oligoclase. The hornblende occurs as euhedral crystals pleochroic, yellow to dark olive green. The mineral has no reaction rim of magnetite such as is common to the hornblende andesite of Kandavu and Vanua Levu.

IV. Rocks from Vanua Levu.

A. SUMMARY OF THE PETROGRAPHY OF VANUA LEVU AS GIVEN BY GUPPY.

Plutonic Rocks. Three varieties of plutonic rocks are listed by Guppy from seven different localities. All these localities lie along a mountainous ridge, running parallel to Natewa bay, i. e. in a N. E.–S. W. direction.

Hypersthene gabbros or norites are common throughout the district. A hornblende gabbro is described from the extreme southern end of the range and diorites were found in relations which indicate a close association between the two rock types.

Throughout the larger part of Vanua Levu, plutonic rocks are, therefore, very uncommon. They are not found west of a line connecting Savu Savu Bay and Lambasa, nor east of Natewa bay.

Volcanic Rocks. The volcanic rocks of Vanua Levu are grouped by Guppy into an elaborate classification of which the following members are most important:—

olivine basalts,
basaltic augite andesites,
hypersthene-augite andesites,
hypersthene andesites,
hornblende-hypersthene andesites,
dacites,
oligoclase trachytes,
quartz porphyries.

Olivine basalts compose the wide cone at the extreme southwestern end of Vanua Levu, known as Mount Seatura. The flow rocks forming the low lands west of this area are basaltic augite andesites. It is important to note that Guppy (1903, pp. 62–63) speaks of Mount Seatura as a well preserved volcanic cone, having slopes of 3 to 4 degrees which are, in certain cases, unscarred by subsequent erosion. It would appear that this mountain represents a comparatively late period of volcanic activity.

Excepting the region of basalts, just referred to, and another district underlain by rhyolitic types, the volcanic rocks of the rest of the island are prevailingly andesites and are characterized by the mineral hypersthene. Hypersthene-augite andesites are widely distributed from the Mbua district at the extreme western to Kimbalau point at the extreme eastern side of the island.

In a class called acid andesites, Guppy includes hypersthene andesites, hornblende-hypersthene andesites, and quartz-hornblende-hypersthene andesites or dacites. The hornblende of many of these andesites has reaction rims of magnetite and augite such as are common in the hornblende andesites of Kandavu and Mbengha. These rocks are said to "compose in mass, numerous isolated hills that rise up in the interior of the central portion of the island. Such hills, or mountains, as they might be often termed, usually attain a height of from 700 to 1200 feet above the surrounding country, and possess precipitous slopes and frequently perpendicular cliff-faces." From this description it would appear that andesites have been more deeply eroded than the basalts.

Hypersthene andesites are especially common at the northwestern side of the Wainunu tableland in west-central Vanua Levu, also in the district between Savu Savu and Natewa Bays.

Hornblende-hypersthene andesites occur north and northwest of the Wainunu tableland and, in general, are closely associated with the hypersthene andesites. In fact, all the hypersthene rocks grade into each other, from augite andesites with little hypersthene to hypersthene andesites and hornblende andesites with little augite. Hypersthene-bearing dacites are reported from the northwestern slope of the Wainunu tableland.

The district, east of Lambasa, along the northern coast of Vanua Levu, is characterized by rhyolitic rocks. In general the northern half of the peninsula, north of Natewa Bay, and, as well, the whole end of the peninsula near Undu Point, are composed of these rocks. The boundary, between the hypersthene andesites to the southwest and the rhyolites to the northeast, is an irregular line. Guppy does not state the relative ages of these rocks. The writer formed the opinion, from a study of the district east of Lambasa, about Mount Avuka, that the rhyolites were the first to be extruded. Oligoclase trachytes occur at the extreme northeastern end of Undu Promontory in association with quartz porphyries. Along the northern coast pumice-tuffs are most frequently found.

B. DESCRIPTION OF ROCK TYPES COLLECTED BY THE WRITER.

The writer was able to visit but a few places in Vanua Levu and hence can add little to the work already done by Guppy. The facts concerning rock distribution coincide with those already outlined. Rocks from four districts only will be described.

1. *Rocks from the Mbutha Bay District.*

a. A porphyritic, greenish-gray *basalt* was collected from a sill in the agglomerates which, with ash-beds, form the country rock of most of the district about Mbutha Bay. The exact locality lies midway between Mbutha and Natewa Bays at an elevation of above 1700 feet.

The feldspar phenocrysts usually have the composition of medium labradorite ($Ab_{40}An_{60}$), but a few are zoned, showing an outer zone of andesine, ($Ab_{58}An_{42}$), an intermediate zone of acid labradorite, ($Ab_{45}An_{55}$), and an inner zone of anorthite (Ab_5An_{95}).

The ground-mass is diabasic.

b. Hypersthene basalt was found in a boulder of an agglomerate on the south bank of the Mbutha River, 1¼ miles from its mouth. The rock is grayish white in color, compact, and finely granular. The dark phenocrysts are chiefly hypersthene; a few small brown hornblendes may be seen. Beautifully zoned feldspars abound. They consist of four layers, an outer of acid andesine, ($Ab_{63}An_{37}$), the next of basic andesine, ($Ab_{55}An_{45}$), which also forms the innermost zone, and a third of basic labradorite, ($Ab_{28}An_{72}$).

The ground-mass has a trachytoid texture and consists of feldspar with abundant minute grains of magnetite. There is some evidence of devitrification.

2. *Rocks from the Lambasa District.*

a. Gabbro. Gabbro forms a low, rolling topography along the divide between the Ngawa and Mbutha Sau rivers just east of Lambasa. The eroded gabbro surface was submerged and covered by marine ash-deposits and basaltic flows; subsequent uplift permitted further erosion to uncover the gabbro.

The specimen to be described was collected from the crest of the divide, at an elevation of 1500 feet. It is a medium-grained, iron-gray rock consisting of feldspar and augite. The laths of feldspar are 3 to 4 mm. long and 1 to 2 mm. wide and between them in diabasic arrangement is a felted mass of fibrous augite and hornblende. The rock breaks irregularly and is but slightly altered.

The weight proportions of the essential minerals are: —

Augite and uralitic hornblende	14.3
Feldspar	84.8
Iron ore	.9
	100.0

The larger part of the feldspar is a medium labradorite, ($Ab_{40}An_{60}$). Zoned feldspars show the following composition, passing from the inner to the outer zones: —

Anorthite	Ab_5An_{95}
Basic labradorite	$Ab_{25}An_{75}$
Medium labradorite	$Ab_{40}An_{60}$
Andesine	$Ab_{65}An_{35}$

The augite is in irregular, shattered bits, some of which are included in the outer zones of the feldspars.

The gabbro has the following chemical composition: —

SiO_2	50.01
TiO_2	1.01
Al_2O_3	19.33
Fe_2O_3	1.85
FeO	6.26
MnO	.21
MgO	3.51
CaO	12.38
Na_2O	2.13
K_2O	0.18
P_2O_5	trace
H_2O+	1.85
H_2O-	1.55
Total	100.27

Norm	
Quartz	5.40
Orthoclase	1.11
Albite	17.82
Anorthite	42.53
Diopside	15.62
Hypersthene	9.78
Magnetite	2.78
Ilmenite	1.98
Water	3.40
Total	100.42

Specific Gravity at 20°C = 2.753
Analyst — P. C. Voter.

Its position in the norm classification is:—

Class III	Dosalane,
Order 5	Germanare,
Rang 4	Hessase,
Subrang 3	Hessose.

b. Basalt. Porphyritic basalts are found throughout the Lambasa valley. They overlie the gabbro just described and form agglomerates composing the bulk of the peaks of the Three Sisters and Mount Avuka. The specimen to be described was taken from a limestone-covered ridge, jutting out into the delta plain a mile and a half northwest of Lambasa.

Phenocrysts of diallage are associated with more abundant phenocrysts of plagioclase ($Ab_{60}An_{40}$, to $Ab_{40}An_{60}$) in the rock. Due to decomposition, epidote is abundant in the ground-mass associated with feldspar and augite. Magnetite dust is also present in large amount. The structure of the ground-mass is diabasic.

The feldspars are zoned, but difficult to determine because of decay. The average feldspar approaches a basic andesine and hence the rock in places verges into basaltic andesites.

c. Foraminiferal Basaltic Ash. A number of hills rising to an elevation of approximately 160 feet dot the Lambasa flood plain. They are composed of fine, greenish ash of basaltic composition, doubtless allied in origin with the basalt of the adjacent hills.

The ash is well cemented into a compact, greenish-gray rock of very fine texture. The grain is, however, coarser than that of the marls of the Suva district. Foraminiferal tests indicate that the deposit was laid down beneath the sea.

d. Andesitic Porphyrite and Pitchstone. The shore east of the Mbutha Sau river, near Lambasa, is composed of a fine, grayish white, rhyolitic ash. The ash is occasionally intruded by slightly vesicular, porphyritic dikes, having pitchstone contact-facies against the rhyolite. The dike rock described below occurs on Salia Levu Point, near Wavu Wavu.

The rock is slate-gray in color, massive, and shows an occasional minute feldspar in an aphanitic ground-mass.

The feldspar phenocrysts have the composition, oligoclase-andesine, ($Ab_{70}An_{30}$), and the ground-mass is composed of feldspar and glass with a hyalopilitic texture.

3. *Rocks from the Savu Savu Bay District.*

a. Hypersthene Basalt. Along the seaward side of the peninsula forming the southeastern boundary of Savu Savu Bay, there are several masses of elevated limestone. The largest mass is cut by a river-valley broadening toward the sea. The western remnant, near the village of Nandi, is underlain by a basalt flow and calcareous agglomerate, passing upward into conglomerate and the coralliferous limestone mentioned. The change from volcanic activity to the deposition of coralliferous limestone was accomplished in a comparatively short time. Specimens were collected from the underlying flow and from a boulder enclosed in the limestone. They were found to be identical. The specimen from the flow will be described.

The rock is iron-black in color and shows needles of feldspar (5 to 8 mm. in length) abundant in an aphanitic ground-mass. Occasional phenocrysts of augite are found and an inclusion of silicified limestone.

All the phenocrysts are euhedral or subeuhedral. An older generation of feldspar phenocrysts is much clouded by inclusions of glass. They show renewed growth. The augite phenocrysts are on the contrary resorbed. One augite crystal has a core of hypersthene.

The zoned feldspars show the following composition: —

Outer zone.........andesine, $Ab_{63}An_{37}$
Central zone.......labradorite, $Ab_{47}An_{53}$
Inner zone.........basic labradorite, $Ab_{35}An_{65}$

The average feldspar is medium labradorite.

The structure of the ground-mass is hyalopilitic.

b. Basalt. The ridge between Savu Savu and Natewa Bays near Valanga is composed largely of agglomerates interbedded with flows. The agglomerates are olive-gray in color and are composed of ash with angular bits of olivine basalt. On the other hand, the specimens of flow rock lack olivine.

The flow rock is slate-gray in color and consists of abundant, small, augite phenocrysts, 2 to 3 mm. in length, set in an aphanitic groundmass. Feldspar (Ab_{45} An_{55}) laths of the same size are so like the ground-mass in color that they are indistinct in the hand specimen.

4. *Rocks from the Divide between the Lambasa and Savu Savu Bay Districts.*

a. Basaltic Conglomerate. The crest of the divide between Lambasa and Savu Savu Bay is formed of conglomerate rocks containing rounded pebbles of basalt 1 to 2 cm. in diameter. Some of the pebbles are green, others slate or brick-red color according to their degree of alteration. Their structures vary from porphyritic through glassy to scoriaceous. They are set in an ashy paste. Lower down on the slopes of the ridge, the paste becomes calcareous and the pebbles smaller. Foraminiferal tests and even small shells are sometimes found. It would appear that the present crest of the ridge is not far from the strand-line of the ancient volcanic period. The sediments dip gently to the southwest.

The microscope shows that all the pebbles of the conglomerate are basaltic. The vesicles of the rocks from the crest are filled with chalcedonic amygdules while the lower rocks have calcareous fillings. Olivine and hypersthene are the prevailing ferro-magnesian minerals; the feldspar is a medium to basic labradorite.

b. Gabbro Porphyrite. Descending the crest of the divide on the way from Savu Savu Bay to Lambasa, the first 500 feet is very precipitous. Thereafter the paths along the stream beds are gentler. Near the intersection between the two slopes there are waterfalls at certain dikes which resist erosion better than the adjoining conglomerates. Specimens of the dikes were collected from an altitude of 1100 feet and 800 feet. They proved to be very similar. A specimen from the lower level will be described.

The slightly vesicular rock is iron-gray in color, showing phenocrysts of feldspar, 3 to 4 mm. in length, evenly disseminated in a finely crystalline, felty ground-mass.

Feldspar phenocrysts are very abundant. Very few augite crystals are present. The ground-mass has a typical diabasic texture of coarser grain than the average basalt, hence the rock is referred to as a gabbro porphyrite. The feldspars are usually not zoned but are in laths (as labradorite, Ab_{50} An_{50}). One or two zoned specimens were found having the composition:—

Outer zone, oligoclase, $Ab_{75}An_{25}$,
Middle zone, andesine, $Ab_{58}An_{42}$,
Inner zone, labradorite, $Ab_{43}An_{57}$.

V. ROCKS FROM TAVIUNI.

Thirteen rocks were studied from the collections made in Taviuni. Eleven are olivine basalts; the other two contain basic andesine and are closely related types. Most of the specimens came from the western side of the island, but a few were collected from the eastern shore at its northern and southern extremities. The small island of Vunimbani, off the northeastern shore, is capped with a water-laid ash deposit of fine texture, 20 to 30 feet in thickness. Beneath the ash lies a vesicular olivine basalt closely related to the basalts of the adjacent shore of the main island. The two types have acid labradorite merging into andesine as their feldspar.

The textures of the basalts of Taviuni are generally diabasic; in two cases the ground-mass has pilotaxitic texture while a third rock shows a trachytoid arrangement of its feldspar needles.

The rocks were collected from widely separated localities and are considered to be typical. Two varieties only will be described.

(1) *Andesitic Basalt.* The northeastern slopes of Taviuni are covered at intervals by a series of recent flows emanating from two well preserved, accessory cones. The flows rest upon a lateritized surface of vesicular basalt having a composition very similar to the more recent lavas. The specimen described is from a recent flow at Nangasau.

The rock is fresh, highly vesicular, slate-gray in color and has a cryptocrystalline ground-mass in which are many minute phenocrysts of feldspar and olivine. The phenocrysts are hardly noticeable in the hand specimen.

The olivine phenocrysts are euhedral and larger, as well as more abundant, than the plagioclase phenocrysts. The plagioclase phenocrysts are zoned and have a composition varying from $Ab_{55}An_{45}$ to $Ab_{50}An_{50}$ or from basic andesine to acid labradorite.

The ophitic ground-mass consists of olivine and plagioclase with abundant minute bits of iron ore.

(2) *Olivine-gabbro Porphyrite.* Near the center of Taviuni, back of the village of Somo Somo, there is an extinct crater whose walls have not yet been breached by erosion. From the outer slope of the western walls, at an elevation of approximately 4000 feet, the rock to be described was collected.

It is a fresh, massive, slate-gray rock containing abundant phenocrysts of feldspar (8 to 10 mm. in diameter) with augite and olivine phenocrysts of the same size but less abundant.

The phenocrysts are large augite crystals, zoned feldspars, and less numerous olivine crystals.

The feldspar phenocrysts are beautifully zoned, showing an outer zone of acid labradorite, $Ab_{48}An_{52}$, an intermediate zone of andesine, $Ab_{79}An_{21}$, and an inner zone of labradorite, $Ab_{42}An_{58}$.

The diabasic ground-mass, composed of plagioclase, olivine, and augite, is much more coarsely crystalline than that for the average basalt and the rock for this reason has been referred to as a porphyrite.

VI. ROCKS FROM THE LAU ISLANDS.

Volcanic rocks were collected from the following islands of the Lau Group. The specimens will be described from the islands in the order given:

Vanua Mbalavu,
Yanu Yanu,
Susui,
Munia,
Thikombia-i-lau,
Kanathea,
Tuvuthá,
Lakemba,
Ono-i-lau,
Kambara,
Moala.

Throughout, the order of description will be first andesites, and then basalts. No vesicular types of the andesite were found on Vanua Mbalavu. In general, the andesites and basalts belong to two different periods. Though basalts may occur in the andesitic period, such basalts are not known to contain olivine. The andesites or andesitic basalts were extruded before the deposition of the elevated limestones; the olivine basalts after their deposition.

Vanua Mbalavu.

1) *Andesite from southwestern side.* The andesite was found as a small, laccolithic mass injected into tuffs and agglomerates and exposed in a sea-cliff at the southern side of a point of land just south of Ndaku-i-Loma Loma.

The rock is oily, dark gray in color, holocrystalline and without noticeable phenocrysts in the hand specimen. In thin section a very few small phenocrysts of andesine ($Ab_{59}An_{41}$) may be seen. These phenocrysts are set in a very fine paste of augite and feldspar, showing a pilotaxitic texture. There is an abundant sprinkling of fine bits of magnetite and secondary epidote has developed.

2) *Andesite from the western side.* The andesite in question came from the coast near the roadstead indicated on the charts. It occurs in cliffs cut about the bases of mature hills.

It is a slate-black, porphyritic rock. Abundant large phenocrysts of feldspar, 10 to 13 mm. in diameter, and less conspicuous augites are set in a ground-mass consisting largely of glass with disseminated augite, feldspar, and magnetite.

The feldspar phenocrysts are very irregularly intergrown and twinned. Most of them are zoned and show a composition varying from $Ab_{65}An_{35}$ to $Ab_{47}An_{53}$. The feldspar of the ground-mass is andesine, $Ab_{65}An_{35}$.

3) *Basalt from Koro Mbasanga.* Koro Mbasanga is the highest peak in Vanua Mbalavu. It rises in the north central part of the island. Two specimens of basalt were collected; one from the floor of the breached crater and the other from a spur ridge south of the summit. Their textures vary but their composition is similar. The specimen from near the summit is holocrystalline and fine-grained with very small phenocrysts. The other has larger phenocrysts, the olivine, especially, being distinct. The latter specimen will be described.

The rock is gray-black in color, holocrystalline, and porphyritic. The feldspar phenocrysts are 2 to 3 mm. in diameter while those of olivine are 5 to 8 mm. in diameter. Abundant large phenocrysts of olivine and smaller ones of augite and feldspar appear in the slide. Augite, feldspar, pyrite, magnetite, and a little olivine compose the ophitic ground-mass. The feldspars are zoned labradorites, varying in composition from $Ab_{43}An_{57}$ to $Ab_{38}An_{62}$.

4) *Vesicular basalt from Mua Mua.* On the western side of Vanua Mbalavu, somewhat south of the center of the island, there is a mangrove swamp. At its northern edge the swamp abuts directly against rather steep slopes of sub-Recent, porphyritic lavas. These lavas are fresher than most of the other rocks of the island, in spite of the fact that they are very vesicular.

The olivine phenocrysts are large and euhedral. The feldspar, a medium labradorite, ($Ab_{40}An_{60}$) occurs in short, stubby laths. The ground-mass is largely feldspar with a few minute olivine crystals in the interstices. Some augite is also present.

5) *Basalt from the north side.* This basalt occurs within a valley in the limestone, 4 to 5 feet above sea-level, just north of the point forming the northern side of the bay at Dalithoni.

It is a fresh dark purple, vesicular rock, with a very fine holocrystalline structure. Phenocrysts of feldspar, 5 to 7 mm. in diameter, occur in an aphanitic ground-mass.

In thin-section an occasional augite phenocryst is seen to be associated with the feldspar. The ophitic ground-mass is largely composed of augite with disseminated feldspar crystals. Both generations of feldspar are labradorite, $Ab_{40}An_{60}$, though some of the crystals are zoned.

6) *Andesitic Basalt from Tota.* Tota is situated at the juncture of the volcanic rocks with the limestones on the northeastern shore of Vanua Mbalavu. Just south of the village low spurs from the volcanic hills jut out into the sea. To the northwest abrupt limestone cliffs rise from a narrow beach. Inland there is evidence that the limestone overlies the volcanic rocks. The andesite here described was collected from the volcanic spurs south of the village, but its relations to the limestone is uncertain. It is believed, however, to represent a flow from the basaltic cone of Koro Mbasanga rather than to be allied to the andesite underlying the limestone.

The rock is reddish brown in color, holocrystalline and fine grained. Phenocrysts of feldspar and diallage are evenly disseminated through the rock. Larger olivine phenocrysts are not so common. The ground-mass is composed of augite and feldspar in intersertal relation, associated with magnetite particles and some olivine.

The feldspars are zoned and show a composition varying from $Ab_{56}An_{44}$ to $Ab_{48}An_{52}$ or from basic andesine to acid labradorite. The texture of the ground-mass is coarser than that of the average rock studied. Minute inclusions which appear to be olivine are sometimes found in the feldspars.

The analysis of the basalt is as follows: —

SiO_2	55.75
Al_2O_3	16.53
Fe_2O_3	0.53
FeO	7.14
MgO	3.19
MnO	0.55
CaO	9.12
Na_2O	4.24
K_2O	0.95
H_2O (below 100°C)	1.04
H_2O (above 100°C)	0.51
CO_2	0.32
Total	99.87

Norm	
Quartz	1.50
Orthoclase	6.12
Albite	35.63
Anorthite	23.27
Diopside	18.62
Hypersthene	12.13
Magnetite	0.70
	97.97
Water	1.55
CO_2	0.22
Total	99.74

Specific Gravity at 20°C = 2.845
Analyst, L. F. Hamilton.

Its position in the Norm classification is: —

Class II	Dosalane,
Order 5	Germanare,
Rang 3.	Andase.
Subrang 4	Andose.

Yanu Yanu.

1. *Andesite.* This rock forms dikes, 3 or 4 feet wide, cutting ash beds, on the eastern side of the island.

The rock is purplish brown in color. Phenocrysts of andesine, $Ab_{65}An_{35}$ to $Ab_{60}An_{40}$, in laths 3 to 4 mm. long, occur in a vitreous ground-mass, bearing microcrysts of feldspar.

2. *Olivine Basalt.* The island of Yanu Yanu rises in a cone, 270 feet high. Its main mass is made of the rock described below which was collected from the summit of the island.

The basalt is fresh, massive, nearly black, holocrystalline, and medium to fine-grained.

In thin section abundant small phenocrysts of olivine are seen with other phenocrysts of augite and feldspar. The ophitic ground-mass contains abundant augite, some olivine, considerable andesine, $Ab_{60}An_{40}$, and magnetite.

The analysis of the basalt is as follows: —

SiO_2	48.56
TiO_2	2.40
Al_2O_3	16.30
Fe_2O_3	2.04
FeO	8.61
MnO	0.10
MgO	8.76
CaO	8.22
Na_2O	2.04
K_2O	0.70
H_2O	1.60
P_2O_5	0.30
	99.63

Norm	
Quartz	.78
Orthoclase	3.89
Albite	17.29
Anorthite	33.36
Diopside	4.51
Hypersthene	29.87
Magnetite	3.02
Ilmenite	4.56
Apatite	.62
	97.90
Water	1.60
	99.50

Specific gravity at 20°C = 2.889

Its position in the Norm classification is, therefore:—

Class III	Salfemane
Order 5	Gallare
Rang 4	Auvergnase
Subrang 3	Auvergnose.

Basalts erupted from Kilauea, Hawaii in May, 1883, have a composition very similar to the basalt described above, (Washington, 1903, p. 337).

Susui.

1. *Andesite.* Andesite forms glassy flows, 8 to 10 feet thick, just northeast of the town of Susui. The flows strike about E–W and dip 30° S. They are vesicular near their top and elsewhere have a platy structure.

The rock is slate-black in color but often has a reddish tinge due to the formation of hematite. It is massive and porphyritic. The phenocrysts of andesine, $Ab_{63}An_{37}$ to $Ab_{59}An_{41}$, and augite are small (1 to 2 mm. in diameter).

The ground-mass is composed of minute laths of feldspar in a glassy matrix.

2. *Basalt.* Interbedded flows of basalt form a point at the extreme eastern end of Susui. The flows dip 25 to 30° S. W. The specimen to be described was collected near sea-level.

The fresh rock is slate-gray in color, massive and porphyritic. It is holocrystalline and very fine-grained.

The phenocrysts visible in the thin section are feldspar, olivine, and augite. The olivine phenocrysts are most abundant, though the feldspars are more distinct in the hand specimen. The feldspars are labradorite, $Ab_{40}An_{60}$ to $Ab_{25}An_{75}$.

There is very little olivine in the pilotaxitic ground-mass and the approximate proportions of feldspar and augite are 60 to 40.

Munia.

Olivine basalt. Massive flows, interbedded with ash and agglomerate deposits, form the abrupt slopes of the eroded crater of Munia. The writer collected five specimens from the flows and from boulders in the agglomerates. They differ only in structure. The rock to be described was taken from a flow in the east central part of the island at an elevation of 200 feet.

The basalt is slate-gray in color and fine-grained. An occasional feldspar phenocryst, 4 to 5 mm. in length, may be seen, but usually the feldspar is in the form of minute needles associated with small augite crystals, 1 to 2 mm. in diameter. The rock is very fresh and breaks with conchoidal fracture.

Phenocrysts of augite, olivine and plagioclase feldspar are abundant in the thin section. The ground-mass, with occasional traces of a diabasic texture, is composed of augite, olivine, feldspar, and glass with abundant magnetite dust.

The feldspar phenocrysts show zonal inclusions and frequently are zoned, having the composition, $Ab_{42}An_{58}$, labradorite, and $Ab_{23}An_{77}$, bytownite.

Thikombia-i-lau.

1. *Andesitic Basalt.* A little to the east of the extreme southwestern point of Thikombia-i-lau is a point of land, built up of a coarse agglomerate. Cutting the agglomerate is a dike of basalt, 5 to 6 feet in width. This intrusive is fine-textured and porphyritic. It is fresh, dark gray, almost black, in color. Augite (diallage) and labradorite ($Ab_{40}An_{60}$) phenocrysts, 2 to 3 mm. in diameter, form 30 per cent of the rock. The structure of the ground-mass is hyalopilitic.

The chemical composition is as follows: —

SiO_2	58.30
TiO_2	0.80
Al_2O_3	17 10
Fe_2O_3	2.10
FeO	5.58
MnO	0.08
MgO	2.70
CaO	7.40
Na_2O	3.72
K_2O	0.83
H_2O	1.15
P_2O_5	0.22
	99.98

Norm	
Quartz	12.36
Orthoclase	5.00
Albite	31.44
Anorthite	27 52
Diopside	6.93
Hypersthene	10.74
Magnetite	3.02
Ilmenite	1.52
Apatite	.31
	98.84
Water	1.15
	99.99

Specific gravity at 20°C = 2.700

Its position in the Norm classification is: —

Class II	Dosalane,
Order 4	Austrare,
Rang 3	Tonalase,
Subrang 4	Tonalose.

The lavas of Bandai San, Japan, approach the composition of the basalt from Thikombia and also a lava from a volcano on New Britain Island, Pacific Ocean. The Bandai San lavas are described as andesites and undoubtedly the rock just described has a composition more closely allied to an andesite than to a basalt but since its feldspars are largely labradorite it is called a basalt. The lavas of Crater Lake, Oregon, are also similar to the rock here described.

2. *Vesicular Basalt.* This specimen was broken from an angular boulder in the agglomerate which constitutes a small cape near the middle of the south shore of Thikombia-i-lau.

The fresh basalt is a very spongy, vesicular type with fine vesicles. It is dark gray in color and porphyritic.

The feldspar phenocrysts are 2 to 3 mm., occasionally 8 to 10 mm., in diameter. They are zoned and the zones are frequently outlined by glass inclusions. They have the average composition of labradorite, $Ab_{45}An_{55}$ to $Ab_{40}An_{60}$. The augite is a diallagic variety.

The ground-mass has a hyalopilitic texture. Feldspar and augite, in the approximate proportion of 70 to 30, and abundant magnetite are present in the glass.

Kanathea.

Olivine basalt. Three specimens of basalt from Kanathea were examined. One came from sea-level at the northeastern side of the island; another was collected at an elevation of approximately 20 feet within the central valley; and a third was taken from the summit of a high cliff at the southern side of the central valley. All three have approximately the same composition. A typical specimen will be described. This rock occurs as a sill intruded into the agglomerate near sea-level.

It is very dark gray, massive, holocrystalline, and fine-grained. The augite and olivine phenocrysts are 4 to 5 mm. in diameter; the zoned labradorite phenocrysts ($Ab_{57}An_{43}$ to $Ab_{43}An_{57}$) are smaller. The ground-mass is diabasic.

Tuvuthá.

1. *Basalt.* The specimen to be described was collected from the lateritized summit of the central ridge of Tuvuthá near an isolated remnant of limestone, unconformably overlying the basalt.

The light, purplish gray, porphyritic basalt has zoned feldspar phenocrysts 4 to 5 mm. in diameter, the zones often outlined by inclusions of glass. The composition of the feldspar varies from a basic andesine to a basic labradorite, $Ab_{52}An_{48}$ to $Ab_{30}An_{70}$. The feldspar of the ground-mass occurs in small laths and appears to average a labradorite.

The phenocrysts of augite have the usual characteristics.

The structure of the altered ground-mass was originally vitrophyric-porphyritic.

2. *Olivine Basalt.* A point of land 60 to 75 feet high rises just south of the village of Tuvuthá. The seaward face of the hill is composed of a calcareous breccia. The specimen was taken from a fragment in the breccia.

The rock is dark gray in color, massive and porphyritic. The phenocrysts of augite and feldspar vary from 3 or 4 mm. to 8 or 10 mm. in diameter. They are accompanied by abundant olivine phenocrysts. The feldspar phenocrysts are not zoned. They have the composition of a medium labradorite, $Ab_{40}An_{60}$. The augite phenocrysts give evidence of a second stage in their growth.

The structure of the ground-mass is vitrophyric-porphyritic.

Lakemba.

1. *Andesite.* Just east of the village of Wathiwathi at the southeastern side of Lakemba, there is a point of land composed of agglomerates and flows. These are cut by a perpendicular dike 12 feet wide and very glassy near its edge. The specimen was collected from the glassy edge.

The andesite is jet black in color, aphanitic and slightly vesicular. It has the macroscopic appearance of a glass and breaks with a conchoidal fracture. Minute phenocrysts of feldspar, 1 mm. long, are disseminated through the glass. The rock is very slightly altered.

The phenocrysts are feldspar and augite. The feldspars are zoned and have the composition of andesine, $Ab_{63}An_{37}$ and $Ab_{56}An_{44}$. Carlsbad twins are frequent.

The glass of the ground-mass bears no augite, consisting only of a felt of feldspar needles with magnetite grains.

2. *Olivine basalt.* The government schoolhouse at Thoumbo stands on a low spur from the central hills. The spur has a veneer of limestone but, beneath, lies a series of flows and agglomerates which are deeply lateritized. The basalt was collected from a residual boulder about one hundred yards northeast of the schoolhouse.

The rock is dark gray in color, massive and coarsely porphyritic. Feldspar phenocrysts (labradorite, $Ab_{40}An_{60}$), 10 to 15 mm. in diameter, form 40 to 50 per cent of the rock. The rock is remarkable in having no augite phenocrysts. The olivines are small and scattering.

The ground-mass is an ophitic aggregate of minute crystals of augite and feldspar.

Ono Group.

1. *Vesicular andesite.* Ndoi consists of agglomerate and flows dipping north and northeast. Its summit, at an elevation of 279 feet, is composed of agglomeratic rocks. This specimen was broken there from a boulder in the agglomerate. The andesite has a spongy vesicular structure, with the vesicles elongated in the direction of flow. The rock is slate-drab in color.

The microscope shows that a glassy rim, altered to kaolin, surrounds the vesicles, between which is a mat of feldspar needles. The feldspar is a medium andesine, $Ab_{62}An_{38}$.

The ground-mass is hyalopilitic.

2. *Olivine andesite from Ndoi.* Interbedded lava flows stand up as hog-back ridges between ash and agglomerate deposits on the northwestern side of Ndoi. The specimen was collected from one of these flows.

The rock is highly vesicular and grayish brown in color. The feldspar phenocrysts are most abundant. They are of two generations. The first generation are large, zoned, and show inclusions of glass regularly arranged. Large augite phenocrysts are of the same generation. The second generation are smaller and show less distinct lines of growth. The zoned feldspars have the composition of medium andesine and acid labradorite, $Ab_{59}An_{41}$ to $Ab_{48}An_{52}$. Andesine occurs in the ground-mass.

Small olivine phenocrysts are scattered through the ground-mass and are associated with the second generation of feldspars.

The texture of the ground-mass, little else but a mat of feldspar, is pilotaxitic.

3. *Basalt.* The basalt in question was taken from a dike cutting the olivine andesite just described.

It is gray in color and slightly vesicular. There are no phenocrysts distinct in the hand specimen. The general structure of the ground-mass is pilotaxitic but near the vesicles it is hyalopilitic. The rock is chiefly composed of a mat of small labradorite (Ab$_{33}$An$_{67}$) needles with occasional phenocrysts of labradorite and rather rare phenocrysts of augite.

4. *Olivine andesite from Ono Levu.* The rocks of Ono Levu are very similar to those of Ndoi. The andesite to be described was collected from the outcrop of a flow, forming the summit of a flat hill at the northwestern end of the island.

The rock is slate-black to dark purple in color. It is massive and porphyritic, with phenocrysts of feldspar, 4 to 6 mm. in diameter, forming 30 per cent of its mass. Augite phenocrysts of a like size form 10 per cent of the rock.

The feldspar crystals are frequently zoned but vary only slightly in composition. They are a basic andesine, Ab$_{57}$An$_{43}$. The augite phenocrysts are twinned on the front pinacoid. There are very few olivine phenocrysts.

The ground-mass has a hyalopilitic texture but there is little glass present. Minute needles of feldspar form the larger part of its composition; magnetite is present.

The absence of abundant olivine phenocrysts in the rock reveals the fact that it is not very basic. This conclusion is borne out by the following analysis:—

SiO_2	52.08
TiO_2	1.40
Al_2O_3	17.86
Fe_2O_3	2.22
FeO	5.76
MnO	0.10
MgO	3.89
CaO	8.20
Na_2O	3.67
K_2O	2.07
H_2O	2.35
P_2O_5	0.36
	99.96

Norm	
Orthoclase	12.23
Albite	31.44
Anorthite	25.85
Diopside	9.98
Hypersthene	11.16
Olivine	0.17
Magnetite	3.25
Ilmenite	2.74
Apatite	0.93
	97.75
Water	2.35
	100.10

Specific gravity at 20°C = 2.792.

The position of the rock in the Norm classification is:—

Class II	Dosalane,
Order 5	Germanare,
Rang 3	Andase,
Subrang 4	Andose.

Kambara.

Olivine Basalt. A thick dike of olivine basalt has broken through the limestone at the northwestern side of Kambara and stands up in the hill Ndelai Yaloi. Several specimens of the rock were collected of which three were studied. One of these was collected at the lower contact of the dike, another was taken from the upper contact, while a third came from a zone some 15 to 20 feet from the upper contact.

The general characteristics of all these rocks are the same. They vary, however, in their texture and in the amount and variety of their phenocrysts. Near the upper contact the rock is very vesicular and has large vesicles 15 to 20 mm. in diameter. Here olivine phenocrysts are abundant but augite and feldspar phenocrysts are lacking. Towards the center of the dike, the feldspar and augite crystals increase in abundance and the vesicles become smaller.

The basalt from the top of the hill of Ndelai Yaloi will be described. The contact is 15 to 20 feet south of the summit.

The rock is drab-gray in color, very fine, even-grained and somewhat vesicular. Phenocrysts of olivine 5 to 8 mm. in diameter are seen but the small augite phenocrysts are less distinct.

Feldspar occurs only as fine needles in the ground-mass. It has the composition of basic andesine, $Ab_{60}An_{40}$.

The olivine phenocrysts are euhedral, but the augites are irregular and resorbed.

The intersertal ground-mass contains olivine, augite, and feldspar. Serpentine, kaolin and hematite have developed by weathering.

The analysis of this rock is:

SiO_2	45.63
Al_2O_3	15.56
Fe_2O_3	3.12
FeO	10.81
MgO	8.64
MnO	0.24

Norm	
Orthoclase	6.67
Albite	11.00
Anorthite	33.36
Diopside	20.38

CaO	11.52	Hypersthene	4.71
Na_2O	1.26	Olivine	18.06
K_2O	1.11	Magnetite	4.41
H_2O (below 100°C)	0.65		98.59
H_2O (above 100°C)	0.80	Water	1.45
CO_2	0.40	CO_2	0.40
Total	99.74	Total	100.44

Specific gravity at 20°C = 2.948.
Analyst, L. F. Hamilton.

The position of the rock in the Norm classification is: —

Class III..................Salfemane,
Order 5...................Gallare,
Rang 4...................Auvergnase,
Subrang 3................Auvergnose.

The basalt from Kambara resembles a basalt from Kilauea, Hawaii, described by J. D. Dana in the American Journal of Science, (3) volume 18, page 134, (1879).

Moala.

Olivine basalt. The writer did not visit the island of Moala but Dr. St. Johnston of Loma Loma kindly presented a few specimens. They are all typical olivine basalts, differing only in structure.

V. ROCKS FROM KANDAVU.

All the specimens from Kandavu were collected during a rapid survey of the southern coast of the island, east of Vunisea. A large number of villages were visited. Most of them are situated on spur hills, 60 to 75 feet high, along the coast. Usually these hills were deeply lateritized and the specimens were collected from residual boulders, lying on the surface.

1) *Trachytoid Andesite.* The specimen was collected from a residual boulder on a lateritized hill, 75 feet high, near the village of Na Vora.

The rock is light yellowish gray, holocrystalline and fine-grained. It is nearly devoid of femic minerals. A few small phenocrysts of augite and feldspar may be seen under the microscope, but the ground-mass forms, on an average, 90 per cent of the rock. The feldspars forming the ground-mass are larger than usual and show a flow arrangement with small, rounded augites in the interstices. The feldspar has the composition of a basic andesine or acid labradorite, $Ab_{52}An_{48}$.

The texture of the ground-mass is exceptional for Fijian lavas and may be called trachytoid.

2) *Hornblende Andesite.* Hornblende andesites of practically the same composition are very widespread in Kandavu. They have been described by Wichmann (1882, p. 32) from the island of Ono, by Eakle (1899, p. 586) from Mount Washington, a very recent cone, and by Renard (1888, p. 149) from Vunisea. The specimens collected by the writer, were found at Vunisea, Joma and Namata. A typical specimen from Namara will be described.

The fresh andesite is bluish gray in color, hypocrystalline, and porphyritic. There are abundant phenocrysts of feldspar, 10 to 12 mm. long and 4 to 6 mm. wide; large hornblende needles, 5 to 6 mm. long, are also plentiful. Euhedral phenocrysts of diallagic augite are also present.

The hornblende has an opaque reaction rim about it, such as Renard (1888, p. 151) described as consisting of magnetite and secondary diopside. Though the hornblende has changed to diopside within its mass, the larger part of the reaction rim appears to consist of magnetite. The hornblende is a basaltic, pleochroic variety; yellow // X, darker yellow // Y, and olive yellow to brown // Z.

Analysis gave the following result:

SiO_2	59.70
TiO_2	0.45
Al_2O_3	16.59
Fe_2O_3	1.70
FeO	3.56
MnO	0.05
MgO	4.18
CaO	6.18
Na_2O	3.97
K_2O	2.37
H_2O	1.10
P_2O_5	0.22
	100.07

Norm	
Quartz	7.80
Orthoclase	14.46
Albite	34.06
Anorthite	20.02
Diopside	8.06
Hypersthene	11.10
Ilmenite	.91
Magnetite	2.55
Apatite	.31
	99.27
Water	1.10
	100.37

The position in the Norm classification is: —

Class II	Dosalane,
Order 5	Germanare,
Rang 3	Andase,
Subrang 4	Andose.

A hornblende andesite from Sepulchre Mountain, Yellowstone National Park, closely resembles the Kandavu variety. (Washington, 1903, p. 275).

3) *Hornblende-biotite Andesite.* The specimen was collected from a series of flows, forming low, late-mature hills near the sea-coast, at Vathilea.

The fresh rock is of a bluish slate color, somewhat vesicular, and porphyritic. Phenocrysts of feldspar and hornblende, 5 to 6 mm. long and 1 to 2 mm. wide, with an occasional olive-tinted biotite, are set in a purplish, light gray matrix.

The phenocrysts of feldspar are most abundant and form 30 to 40 per cent of the rock. They are not zoned and have the composition of a basic andesine, or acid labradorite, ($Ab_{52}An_{48}$).

The hornblende phenocrysts are pleochroic; colorless // X, yellow // Y, and olive yellow // Z. The reaction rims of magnetite, described in the other hornblende andesites, are lacking here. Augite also is absent.

The ground-mass has a pilotaxitic texture and consists almost entirely of feldspar.

4) *Olivine Andesite.* The central segment of Kandavu, east of the hornblende andesite area, which extends to the valley east of Namata, is composed of olivine andesite. Specimens of this type of rock were collected at Matasu and Kama. The specimen from Matasu will be described. It was taken from a residual boulder on a low, lateritized hill, 50 to 60 feet high, near the sea-coast.

The fresh andesite is a dark, slate-colored rock, hypocrystalline, porphyritic, and massive. Rounded phenocrysts of feldspar, 3 to 4 mm. in diameter, and phenocrysts of olivine and augite are scattered through a glassy matrix.

The larger feldspars are more acid and have the composition of an acid andesine, $Ab_{70}An_{30}$, whereas the smaller feldspars, probably a second generation, represent acid labradorite, $Ab_{55}An_{45}$. There are zonal inclusions of glass in the larger phenocrysts.

The augite phenocrysts are repeatedly twinned on the front pinacoid and are distinctly euhedral. Olivine is present, in scattering crystals which have largely altered to serpentine.

The texture of the ground-mass is hyalopilitic.

5) *Olivine Basalt.* A central, N.-S. ridge extends through the island of Ndavuni, which lies north of the island of Ono. At the western foot of this ridge, near the center of the island, the specimen of basalt was collected.

It is fresh, greenish black, holocrystalline and very heavy. Phenocrysts of black augite, 5 to 7 mm. long and 4 to 6 mm. wide, are abundant. Phenocrysts of olivine are less plentiful.

In thin section, small phenocrysts of feldspar are seen to be most abundant. They have the composition of labradorite, $Ab_{45}An_{55}$.

The structure of the ground-mass is pilotaxitic; minute feldspar needles form a mat in which rounded crystals of augite and magnetite occur. The proportion of feldspar to augite is approximately 2 to 1.

Solo Rock.

Andesitic tuff. A single point of rock less than a hundred yards in diameter rises within a circular reef, just north of the Great Astrolabe reef which surrounds Kandavu. On this rock the Solo light-house is situated. The rock is but 8 or 10 feet above the sea. Several specimens, all tuffaceous and andesitic, were collected. Augite, basic andesine, and rare biotite appear in the lava of the fragments.

PETROLOGY OF THE FIJI ISLANDS.

As stated previously, the igneous rocks, collected during the expedition, are not sufficiently numerous or characteristic to serve as a basis for a full petrologic discussion. By comparing personal observations with those of other writers, an attempt will be made, however, to state a few generalizations.

Association of Plutonic Rocks.

Gabbros and diorites have been described from Vanua Levu, and gabbros, diorites, granites, and foyaites, from Viti Levu. Sufficient field-work has not yet been done to show the exact nature of the association, though it is known to be close. The granites and diorites of central Viti Levu, collected by the writer, grade into one another. The texture of the gabbro from the same district allies this rock with the more acid types and it was thought probable that they were all of the same generation.

As the contacts of the plutonic rocks with the sediments which they intruded were not found, no more explicit statement can be made concerning the relations of these rocks.

Volcanic Succession in Viti Levu.

The earliest known lavas in Viti Levu are andesites and rhyolites. No period of erosion is known to separate the flows of these two rock types and they were both extruded in a period preceding the deposition of the folded sediments of the central part of the island. Which of the two types was extruded first has yet to be determined.

After the uplift and folding of the sediments of central Viti Levu, a second period of volcanic activity occurred. This has been referred to as the second andesitic period but in reality basaltic extrusions also occurred in this period. The criteria for rocks of this period are:—1) they have low dips; 2) they overlie the folded sediments of the interior; and 3) pebbles from them occur in the basal conglomerate of the coastal-plains series.

There must have been a considerable period of time between the uplift and folding of the sediments of the interior and the deposition of the coastal-plains series. It is not strange, therefore, to find boulders of olivine basalt in the basal conglomerate underlying the marls near Suva and andesitic pebbles in the analogous basal conglomerate in the Singatoka district.

A study of the distribution of the volcanic rocks in Viti Levu, as given by Cochrane (1911), shows that the coastal hills of the western part of the island, which are assigned to the second andesitic period, are composed of augite andesites and hypersthene-augite andesites. The head waters of the Waimanu and Waindina rivers, northwest of Suva, drain a country underlain by hornblende andesites, though near the coast in the vicinity of Suva, basalts are found.

It is probable that in the period designated as the second andesitic period, a considerable variety of lavas were extruded. The problem of their relative ages has yet to be solved, though from the amount of dissection suffered by the augite andesites and hornblende andesites of western Viti Levu and the Waimanu district, as compared with that affecting the basalts near Suva, the basalts appear to be the more recent.

The volcanic rocks which intrude the uplifted coastal series of southwestern Viti Levu are basalts or basaltic andesites.

The tentative succession of lavas for Viti Levu is, therefore, as follows:—

First epoch — andesite, rhyolite,

Second epoch — hypersthene-augite andesite, hornblende andesite, augite andesite, basalt,

Third epoch — basalt.

Erosion intervals separate the groups. Between the first and second periods of volcanics occurred the folding movements which disturbed the interior sediments.

Comparison of the lavas of Ovalau, Mbengha, and the Yasawa Group with those of Viti Levu.

A hornblende andesite from Ovalau has been described by Wichmann (1882, p. 34). The rocks of Mbengha are basalts, but, while one variety is characterized by olivine and augite, another approaches a hornblende andesite and contains hornblende and augite. The rocks described from the Yasawa group are basalts and hornblende andesites. The prevailing flows of the islands are basalts.

It has been stated previously, (Part I, page 19), that the basalts of the Yasawa group were extruded after the uplift of the limestone islands which belong to the same general period as the coastal sediments of Viti Levu. Because of the relation of the basalts to the Yasawa limestones, the main islands of the group are thought to have been built during the last or basaltic period. The andesites of these islands may, therefore, be remnants of flows dating from the earlier andesitic period. The same may be said for the hornblendic rocks of Mbengha and Ovalau.

Volcanic Succession in Vanua Levu.

The lavas erupted upon the eroded gabbro, near Mount Avuka, are similar to the andesites of Viti Levu which were assigned to the first andesitic period. Pitchstones were found associated with these rocks and it was inferred that certain of the rhyolitic deposits were of the same period; but, in general, the erosion of the rhyolites of northeastern Vanua Levu has not progressed any further than that of the hypersthene andesites. It was, therefore, concluded that some of the rhyolites were extruded in the second andesitic period.

The extrusion of the hypersthene andesites took place, in large part, beneath the sea. Their ash and agglomerates form palagonitic tuffs which were not uplifted until about the same date as the uplift of the marls of the coastal series in Viti Levu.

The second andesitic period of Vanua Levu is considered to have closed with the uplift just mentioned.

From Guppy's description, the olivine basalts forming the promontory at the extreme southwestern end of Vanua Levu, were not erupted beneath the sea; and their sculpturing is so recent that it is believed they were extruded after the uplift of the hypersthene andesites.

In general outline, the succession of lavas in Vanua Levu is not unlike that in Viti Levu. The succession is as follows: —

First epoch — andesite, rhyolite,
Second epoch — rhyolite, hypersthene andesite,
Third epoch — basalt.

It should be stated that the folded sediments of Viti Levu are not found in Vanua Levu and that the deposits of the second andesitic period have no known period of erosion separating them from the first andesitic period. Therefore, it would, perhaps, be preferable to consider the first and second periods, indicated above, as one. For the sake of comparison with Viti Levu, the two periods are retained. In other words, after the erosion of the gabbro of Vanua Levu, the island subsided and was not again uplifted till the period of uplift of the coastal sediments of Viti Levu. During this time of depression, no marls or sandstones are known to have been deposited above the gabbro; instead there are a series of palagonitic tuffs.

Volcanic Succession in the Lau Group.

Three periods of vulcanism have been recognized in the Lau islands. Little is known of the first period which is now represented by pyritized, pumice-tuffs. The lavas of the second or andesitic period are prevailingly andesites, though they are allied to augite basalts and, occasionally, as in the island of Lakemba, carry a little olivine. The analysis of the andesitic basalt from Thikombia-i-lau (p. 126) is typical of this series.

The andesitic period is considered to be contemporaneous with the second andesitic period of Viti Levu and Vanua Levu. In Lakemba, the augite andesites appear to merge into basalts. The occurrence of both basalt and augite andesites in the larger islands has already been noted. It is possible that these types were erupted at approximately the same time and represent phases of a common magma.

The third, or basaltic period, is characterized only by olivine basalts in the Lau Group. The analysis of a basalt from Yanu Yanu (p. 124) is typical of the lavas of the third period.

The volcanic succession is therefore, as follows: —

First epoch — rhyolites?
Second epoch — andesites or basalts.
Third epoch — basalts.

Volcanic Succession in the Kandavu Group.

No unconformities are known between the volcanic rocks of Kandavu and, hence, no exact dates can be assigned to the various rock types. Judging from the erosion of the islands, three periods may be recognized. Near Vunisea, hornblende andesites are eroded to late maturity; farther northeast, augite andesites and olivine andesites are eroded to early maturity. The very recent peak of Mount Washington, is said to consist of hornblende andesites (Eakle, 1899, p. 586). Again, hornblende andesites are described from Ono, which has a submature topography, whereas the northern island of Ndravuni, with a very similar topography, is composed of olivine basalts.

Thus, while hornblende andesites have prevailed in all periods of eruptivity, it is thought that the order, hornblende andesite, augite andesite or basalt, hornblende andesite, approaches nearest the truth.

General Summary of the Volcanic Successions in Fiji.

Reviewing the succession of lavas which have been recorded from the various islands, the first andesitic period is recognized only in the two large islands of Viti Levu and Vanua Levu. Rhyolitic rocks are associated with this period. The second andesitic period is recognized in all the islands in which volcanic rocks are exposed. A diversity of lavas were extruded in this period. From Viti Levu, olivine basalts, hornblende and augite andesites are reported; from Ovalau, hornblende andesites; from Vanua Levu, augite andesite, augite-hypersthene andesite, hornblende andesites, and rhyolites; from the Lau Islands, augite andesites and basalts; and from Kandavu, basalts, augite and hornblende andesites.

The products of the later, basaltic period are not so widespread as those of the previous periods. Basalts are known from Viti Levu; olivine, augite and hornblende basalts from Mbengha; basalts from the Yasawa islands; basalts from Vanua Levu; and basalts from the Lau group.

In view of the diversity of lavas assigned to the second andesitic period, it is important to note that the two most recent eruptions known in Fiji have a very diverse composition. The recent cones of Taviuni gave vent to basaltic flows, whereas Mount Washington, Kandavu, is a hornblende-andesite volcano.

Differentiation in the Lavas of Fiji.

The discussion of the volcanic succession has brought out an important relationship between the rocks of Fiji. In the islands of the Lau Group, which appear to be of recent origin, there is little diversity in the lavas of the two known periods. Basalts, or augite andesites related to basalts, characterize both periods.

On the other hand, within the larger islands, the diversity of lava is great. It is pertinent to inquire, why hornblende is so frequently found in the rocks of Kandavu, Mbengha, Viti Levu and Vanua Levu and is not known on the rocks of the Lau islands.

In most cases, the hornblende gives evidence of being resorbed into the magma and of breaking down into augite and magnetite. It apparently was not in equilibrium with the magma at the time of its solidification. If it is true that hornblende and biotite form only in the presence of magmatic gases, especially water, the loss of these gases on extrusion may be considered to be the cause of the instability of the hornblende in the magma. Thus, in the case of an open vent in which gases were freely given off, hornblende would not form, whereas if the gases were retained for any reason during a period of dormancy, hornblende might develop.

The close association of hypersthene and hornblende in the rocks of Vanua Levu would indicate that the conditions for the formation of the two minerals are quite similar. It is significant that all the hypersthene basalts of Vanua Levu are the results of submarine extrusions. Frank Perret (1917, p. 456) has recently described a flow from Stromboli which entered the sea. He emphasized the rapid formation of a flexible, impervious skin and the slight disturbance produced. It would seem probable that the retention of the volcanic gases under such circumstances would allow hypersthene and hornblende to develop.

Hypersthene and hornblende should, therefore, characterize intermittent and submarine volcanoes, whereas the monoclinic pyroxenes should be found near volcanoes having open vents. The hornblende, hypersthene, and augite andesites are closely related to basalts and are considered to be pure differentiates of a primary basaltic magma. Because of insufficient time it was impossible to make a thorough study of the distribution of lavas about individual volcanic vents. Guppy (1903, pp. 62–65) observed that augite andesites were intimately mingled with olivine basalts in the sub-Recent crater of Mount Seatura, western Viti Levu. The writer observed that the ground-mass of olivine basalts in which zoned feldspars occurred usually contained a feldspar more acid than the phenocrysts and that the ferromagnesian mineral present in such a ground-mass was usually augite. The recent experiments of Bowen (1915, p. 47) practically establish the fact that an augite andesite may differentiate by gravity from an olivine basalt.

In conclusion it may be said that the trend of the volcanic succession in Fiji has been from acid to basic types; yet, while this is true, hornblende andesites have persisted in Kandavu from the first. Another striking fact is the persistency of volcanic vents. Few instances are known in which the later, basaltic eruptions have built up independent craters. On the other hand, a number of examples have been given which show that later basaltic cones were formed on or near earlier andesitic volcanoes.

TABLE OF ANALYSES.

	Tonalite from Central Viti Levu (Yellowstonose)	Olivine Basalt from Lautoka, Viti Levu (Andose)	Basalt from Yasawa Is. (Hessase)	Gabbro from Lambasa, Vanua Levu (Hessose)	Andesitic Basalt from Tota, Vanua Mbalavu (Andose)	Olivine Basalt from Yanu Yanu, Exploring Group (Auvergnose)	Basalt from Thikombia-i-lau (Tonalose)	Olivine Andesite from Ono-i-lau (Andose)	Olivine Basalt from Kambara (Auvergnose)	Hornblende Andesite from Kandavu (Andose)
SiO_2	70.00	47.36	50.06	50.01	55.75	48.56	58.30	52.08	45.63	59.70
TiO_2	00.30	0.85	—	1.01	—	2.40	0.80	1.40	—	0.45
Al_2O_3	14.72	19.38	19.38	19.33	16.53	16.30	17.10	17.86	15.56	16.59
Fe_2O_3	1.36	3.60	1.83	1.85	0.53	2.04	2.10	2.22	3.12	1.70
FeO	2.28	6.13	5.54	6.26	7.14	8.61	5.58	5.76	10.81	3.56
MgO	1.37	5.31	6.53	3.51	3.19	8.76	2.70	3.89	8.64	4.18
MnO	0.04	0.11	0.47	0.21	0.55	0.10	0.08	0.10	0.24	0.05
CaO	3.58	10.54	12.06	12.38	9.12	8.22	7.40	8.20	11.52	6.18
Na_2O	3.70	2.69	1.16	2.13	4.24	2.04	3.72	3.67	1.26	3.97
K_2O	1.68	1.74	0.93	0.18	0.95	0.70	0.83	2.07	1.11	2.37
H_2O-	0.50	2.20	1.14	1.55	1.04	1.60	1.15	2.35	0.65	1.10
H_2O+	—	—	0.37	1.85	0.51	—	—	—	0.80	—
P_2O_5	0.06	0.19	—	trace	—	0.30	0.22	0.36	—	0.22
CO_2	—	—	0.31	—	0.32	—	—	—	0.40	—
Total	99.59	100.10	99.78	100.27	99.87	99.63	99.98	99.96	99.74	100.07

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SIZE VARIATION IN TRACHEARY CELLS:

I. A COMPARISON BETWEEN THE SECONDARY XYLEMS OF VASCULAR CRYPTOGAMS, GYMNOSPERMS AND ANGIOSPERMS.

By I. W. Bailey and W. W. Tupper.

SIZE VARIATION IN TRACHEARY CELLS:

I. A COMPARISON BETWEEN THE SECONDARY XYLEMS OF VASCULAR CRYPTOGAMS, GYMNOSPERMS AND ANGIOSPERMS.[1]

By I. W. Bailey and W. W. Tupper.

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Introduction.

In the study of cell size in plants and animals, much emphasis is placed, during the last thirty years, upon the relations between cell size and body size, organ size and nuclear size. Sachs (1893) calls attention to the fact that, although plants and animals vary enormously (0.001 mm. to 100 m.) in their linear dimensions, there is not a proportional variation (0.001 to 0.05 mm.) in the size of their cells. He formulates (p. 73) the generalization that "zwischen der Grösse der Organe und der ihrer Zellen keinerlei Proportionalität besteht; die Grösse der Organe, zumal homologer Organe, steht vielmehr mit der Zahl der Zellen im Verhältniss." His assistant Amelung (1893) reaches a similar conclusion (p. 187): "Dass nämlich bei morphologisch gleichen Pflanzentheilen trotz der ausserordentlichen Grössenunterschiede doch die mittleren Zellengrössen dieselben bleiben." Strasburger (1893) emphasizes the fact that, although individuals of the same species always show the same size of embryonic nuclei and cells, regardless of variations in the size of their growing points, varieties of these same species may differ greatly from each other.

The conclusions of Sachs and Amelung, in regard to the "fixed size of specific organ-cells," are supported by those of a number of other investigators. For example, Conklin (1896) finds that, in dwarfs of *Crepidula plana*, the cells are of approximately the same size as in normal forms, and (1898) that sexually dimorphic individuals of this species, although differing greatly in body size, are composed of cells of similar sizes. Rabl (1899) considers that the cells of the crystalline lens vary appreciably in number, but not in size. The work of Driesch (1898 & 1900) is particularly suggestive. He shows that in

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[1] This paper was presented in preliminary form at the Columbus meeting of the American Association, December, 1915.

"partial" larvae, derived from isolated blastomeres or egg fragments, and in "double" larvae, from fused eggs, body size is directly proportional to the number of constituent cells. As a result of these observations upon echinids, he concludes (1900, p. 384) that, "die Zellengrösse der zellen einzelner specifischer Organe scheint eine so fest fixirte Grösse zu sein, wie es die optischen Richtungen am Krystall sind." Schnegg (1902), in studying the genus Gunnera, records a number of measurements which corroborate the work of Amelung. Boveri (1904) shows that the epithelial cells, from tongues of dwarfs and giants of the human species, are of the same size as those from individuals of normal stature, and Schultz (1904) states (p. 559): "so will ich für die Planarien wenigstens das Gesetz aufstellen, dass bei Verkleinerung der Form infolge von Inanition die Zellen nicht an Grösse, sondern nur an Zahl abnehmen — und zwar in allen Organen Proportional den Grössen verhältnissen dieser Organe zueinander." Ewart (1906) concludes that, in unusually large leaves, formed upon defoliated trees, there is an increase in the number, but not the size of the cells.[2]

Very different results are secured, however, by another group of investigators. From his study of the spinal cord of the frog, Gaule (1889) is led to place much emphasis upon the constancy of cell number. Donaldson (1895) similarly concludes (p. 162) that "the determination of the number of neuroblasts occurs so early in the history of the individual, and under such uniform conditions, that it is very difficult to regard the environment as possessed of much power to cause variation in this respect." He considers that differences in the weight of the human brain are due mainly to differences in the size of the nerve cells. Hardesty (1902), who made a comparative study of the spinal cords of various mammals, finds that the motor nerve cells are largest in the elephant and smallest in the mouse.

In view of the importance attached to the "Kernplasmarelation" by Gerassimow (1902), Boveri (1905), Hertwig (1903) and others, Gates' (1909) observations upon cell size in *Oenothera gigas*, a tetraploid mutation of *Oe. Lamarkiana*, are of considerable interest. He states (p. 543): "In *O. gigas* we have an organism built of bricks which are larger and whose relative dimensions are also altered in some cases. These two factors will apparently account for all the differences between *O. gigas* and *O. Lamarkiana*, and the second factor may be one merely of readjustment consequent upon the first. It is probable that the number of cells is approximately the same in both cases." Similar phenomena are recorded by Winkler (1916) and Tupper and Bartlett (1916 & 1918). The work of Gregory (1911) and Keeble (1912), on the other hand, indicates that in giant forms of *Primula sinensis*, which have larger cells than normal, there is an increase in the size, but not in the number of chromosomes.

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[2] More recently, Tenopyr (1918) endeavors to prove that differences in the shape of leaves are dependent upon variations in the number rather than the shape of their constituent cells.

Morgan (1904) and Chambers (1908) find that the eggs laid by a given individual may vary greatly in size, and the latter investigator, who questions the doctrine of the fixity of cell size, considers that body size and cell size are proportional to the size of the eggs from which the animals are formed. Popoff (1908) also supposes that body size is determined by the size of the reproductive cells, but Conklin (1912a), as a result of his later investigations upon Crepidula, concludes (p. 186): "In the different species of this genus the size of the germ cells does not determine the size of the adult (Popoff, Chambers). Within the same species differences in body size are due in the main to differences in cell number, the cell size being approximately constant."

It is to be noted, in passing, that in many of these investigations which tend to emphasize the constancy of cell size or cell number in specific animals or plants, scant attention is given to the work of botanists[3] and zoölogists who concern themselves with the study of variations due to environmental factors. Heumann (1850), Morpurgo (1888 and 1889), Frank (1895), Gauchery (1899), Lippold (1904), Stoppenbrink (1905) and Morgulis (1911) describe a number of dwarfs or depauperate plants or animals which are composed of smaller tissue-cells than normal individuals or giants. However, it is noted, particularly by Morpurgo, Gauchery and Morgulis that different categories of tissues may behave very differently during inanition. Kraus (1869–70) emphasizes the fact that the cells of the long internodes of etiolated plants are longer than those of plants grown under normal illumination, and MacCallum (1898) calls attention to the fact that the increase in the musculature of an adult and muscular hypertrophy may be due to an increase, not in the number, but the size of the muscle fibers.

The investigations of Sanio (1872), Haberlandt (1882), Illing (1905),

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[3] The works of Areschong, Brenner, Bonnier, Costantin, Derschau, Dassonville, Dufour, Eberdt, Eberhardt, Frank, Géneau de Lamarlière, Grosglik, Haberlandt, Hesselman, Johow, Kohl, Lesage, Mer, Nordhausen, Pick, Sauvageau, Schuster, Stahl, Tschirch, Vesque, Volkens, Weiss, Zinger and many others, who studied the effects of light, temperature, moisture, nutrition, etc. upon the form and structure of plants, contain numerous incidental references to variations in cell size, but unfortunately few exact measurements.

Berezowski (1910), Yapp (1912), Schramm (1912) and Paulmann (1915) are particularly significant, since they show very clearly that the size of the cells of a given tissue may vary considerably in different parts of an organ or individual and during different stages in its growth or ontogeny.

Hertwig (1903) notes the importance of the fact that the "Kernplasmarelation" is subject to considerable variation during the life of a cell and, therefore, determines this ratio during a particular phase in the development of cells. The results of Conklin's (1912) work upon *Crepidula plana* are of interest in this connection. He states (p. 25): "The results of my measurements do not indicate that the Kern-plasma-Relation of Hertwig is either a constant or self regulating ratio in the blastomeres of these eggs; on the other hand it appears to be a result rather than a cause of the rate of cell division, and consequently it is a variable rather than a constant factor. Furthermore, the size of the nucleus, in these eggs, is dependent upon at least three factors: (1) The initial quantity of chromatin (number of chromosomes) which enter into the formation of the nucleus (Boveri). (2) The volume of the protoplasm in which the nucleus lies. (3) The length of the resting period."

The necessity of distinguishing between purely somatic variations in cell size and those that are truly germinal, is fully appreciated by Jennings (1908), in his careful work upon unicellular organisms. On the botanical side, Zalenski (1904), Kolkunow (1905, 1907, 1907a and 1913) and Jakushkine and Wawilow (1912), in a series of important papers published unfortunately in Russian, show that, although the size of the stomata and guard cells vary considerably in different parts of an individual and under different environmental conditions, there is an inherited norm which varies in different races or varieties of our commonly cultivated cereals. They find that certain of the larger races possess larger stomata, but this is not true in all cases. In his study of nanism, Sierp (1914) emphasizes the necessity of differentiating between true constitutional dwarfs and depauperate plants. He comes to the conclusion that the latter have smaller cells than normal, but finds three classes of inherited dwarfing; dwarfs of Pisum, Solanum, Zea and Clarkia have smaller cells than normal, those of Nigella larger cells than normal and those of Mirabilis and Lathyris cells of normal size. Unfortunately he does not record the size and number of chromosomes in the material investigated by him.

It is evident, accordingly, that not only may different types of size variations occur in different categories of tissues, but also in different types of organisms and under different experimental or enviromental conditions. In certain tissues, in given species or groups of plants or animals, differences in growth or environment produce but slight fluctuations from the norm or inherited cell size. This is not true, however, for all types of cells under all conditions.

That the extensive investigations of the comparative anatomist may be of considerable assistance, as reconnaissance surveys, in the selection of suitable material for more intensive, experimental investigations, and to serve as checks upon too extensive generalization from limited induction, is indicated by the literature dealing with body size and cell size. For example, many difficulties might have been avoided if the work of Levi (1906), upon the size of the various tissue-cells in different groups of animals, particularly mammals, had preceded some of the earlier, more intensive investigations. Therefore, in undertaking a series of investigations upon the size variations of tracheary cells, it seems to be desirable to begin with a reconnaissance survey of cell size in the secondary xylem of vascular cryptogams, gymnosperms and angiosperms.

In selecting this tissue for investigation the writers are influenced by the following considerations: (1) Since the secondary xylem reaches its optimum development in trees, lianas and large shrubs, plants with a long reproductive cycle, it is a more favorable subject for the extensive investigations of the comparative anatomist than the more intensive cultural investigations of the geneticist. (2) From analogy with animal tissues, it seems probable that the dimensions of the highly differentiated tracheary cells of the secondary xylem may fluctuate considerably in response to physiological and environmental influences. (3) Inasmuch as this tissue is one of the most extensively used botanical raw products, an investigation of this character may throw some light upon a number of economic problems, particularly those in the field of the paper-pulp industry.

MATERIAL AND METHODS.

Most of the material, used in the preparation of the following tables, was secured from the extensive collections of the Bussey Institution and Arnold Arboretum. Since the samples of wood and herbarium specimens were collected at different times, and in different parts of the world, by a number of taxonomists and dendrologists, it seems to be advisable to tabulate them as far as possible under their original names and authorities. Of course, these specimens are available for future study and comparison.

In dealing with a considerable number of specimens from various parts of the world, it is extremely difficult to be certain that every specimen has been assigned to the right species, and in some cases to the proper genus. Such errors may be extremely serious in certain types of investigations, but, as will be evident later, can have no appreciable effect upon the general conclusions reached in this paper. The plants are grouped into orders, families and subfamilies, according to the Engler and Gilg (1912) system of classification.

For the purposes of this investigation, simple and septate libriform fibers, as well as fiber-tracheids, tracheids and vessel-segments, are classified as tracheary elements. Fiber-tracheids and libriform fibers grade into one another and appear to be interchangeable in many plants. That is to say, in certain specimens or growth layers there are clearly differentiated bordering areas about the pits, whereas in others thay have almost if not entirely disappeared. Furthermore, it frequently is difficult to determine whether vestigial borders are present or not.

Lengths of tracheary elements were obtained from macerations; widths of vessel-segments, and notes in regard to the general structure of the xylem, from microtome sections ten micra in thickness. All measurements, from 10–100 depending upon the accuracy desired, were made with a standardized micrometer eyepiece. Averages of 50–100 measurements were used as basic points in plotting the graphs. The means given in Tables I and II are usually averages of 10 measurements. The probable errors of these means fluctuate between two and six percent.

SIZE VARIATION OF SECONDARY TRACHEARY ELEMENTS IN STEMS OF GYMNOSPERMS AND DICOTYLEDONS.

In Tables I and II are recorded the lengths of the tracheary elements of a considerable number of gymnosperms and woody dicotyledons. Since the specimens, from which the measurements were made, were secured from different parts of stems, from plants of different ages, sizes, growth habits and systematic affinities, and from different types of environments in various phytogeographic regions of the earth, these data should give a fairly reliable indication of the general size variations that occur in the tracheary elements of the secondary xylem of the stems of conifers and arborescent and fruticose dicotyledons.

TABLE I.

GYMNOSPERMAE.

Secondary xylem: Length of Tracheids in Millimeters.

Designation		Older Wood				First Annual Ring.		
Plant	No.	Age*	Max.	Mean	Min.	Max.	Mean	Min.
I. CORDAITALES.								
1. Cordaitaceae.								
Callixylon Oweni Elk. & Wiel.				4.9+				
Mesoxylon poroxyloides Scott and Malsen				5.2+				
II. BENNETTITALES.								
2. Bennettitaceae.								
Cycadioidea Dartoni Wiel.				5.4+				
C. dacotensis Ward.				5.1+				
III. CYCADALES.								
3. Cycadaceae.								
Dioon spinulosum Dyer.	1528	O	*9.5*	6.8	*4.1*	*7.3*	5.5	*4.1*
Microcycas calocoma A. DC.						*6.3*	4.6	*3.9*
IV. GINKGOALES.								
4. Ginkgoaceae.								
Ginkgo biloba Linn.	707	O	*4.8*	3.5	*2.8*	*1.6*	0.9	*0.6*
V. CONIFERAE.								
5. Taxaceae.								
Podocarpoideae-Pherosphaereae.								
Pherosphaera Hookeriana Archer.						*0.9*	0.7	*0.6*

* Y = less than 20 rings from pith. M = 20–60 rings from pith. O = more than 60 rings from pith.

TABLE I—*Continued.*

Designation		Older Wood				First Annual Ring		
Plant	No.	Age*	Max.	Mean	Min.	Max.	Mean	Min.
Podocarpoideae-Podocarpeae.								
Dacrydium Bidwillii Hook. f.						*0.7*	0.5	*0.3*
Franklinii Hook. f.	726	O	*2.4*	1.9	*1.5*			
Microcachrys tetragona Hook. f.						*0.9*	0.7	*0.6*
Podocarpus bracteata Hort. ex Carr.						*1.3*	1.0	*0.7*
chinensis Sweet.	711	O	*3.7*	2.5	*1.2*			
elata R. Br.	712	O	*4.8*	3.3	*1.7*			
latifolia Wall.	758	O	*6.5*	5.1	*2.6*			
macrophylla D. Don.	C50	M	*3.2*	2.6	*2.3*			
Nageia R. Br.	703	M	*5.0*	3.7	*1.8*			
neriifolia D. Don.	719	M	*5.0*	3.9	*2.6*			
Saxegothaea conspicua Lindl.						*1.2*	1.0	*0.7*
Phyllocladoideae.								
Phyllocladus glauca T. Kirk.						*1.7*	1.2	*0.8*
Taxoideae-Cephalotaxeae.								
Cephalotaxus drupacea Sieb. & Zucc.						*1.1*	0.6	*0.5*
species.	1412	M	*2.7*	2.2	*1.5*			
Taxoideae-Taxeae.								
Taxus baccata Linn.	742	M	*3.1*	2.5	*2.2*			
brevifolia Nutt.	J92	M	*2.1*	1.7	*0.7*			
cuspidata Sieb. & Zucc.	756	M	*2.5*	2.0	*1.5*	*0.8*	0.6	*0.4*
floridana Nutt.	J91	M	2.4	1.9	1.5			
Torreya californica Torr.	J89	O	*3.1*	2.4	*1.4*			

nucifera Sieb. & Zucc.	776	O	*4.3*	3.2	*2.2*	*1.0*	0.7	*0.5*
taxifolia Arn.	761	M	*3.9*	3.2	*2.5*			
6. Pinaceae.								
Araucarieae.								
Agathis australis Steud.	727	O	*7.3*	5.4	*3.3*	*2.1*	1.5	*0.8*
robusta F. M. Bailey.	B10	O	*8.2*	7.1	*4.1*			
Araucaria Bidwillii Hook.	B11	M	*8.8*	6.4	*3.5*			
brasiliensis Loud.	B12	O	*9.4*	6.6	*2.3*			
Cunninghamii Sweet.	723	O	*10.9*	6.2	*2.5*	*1.7*	1.1	*0.7*
imbricata Pav.	B13	M	*4.7*	3.5	*2.2*			
Abieteae.								
Abies bracteata Hook. & Arn.	J528	M	*3.3*	2.7	*1.3*			
concolor Lindl. & Gord.	J56	M	*4.0*	2.5	*0.7*	*1.2*	0.9	*0.5*
firma Sieb. & Zucc.	779	M	*5.5*	4.5	*2.0*			
Fraseri Lindl.	J59	M	*3.9*	3.1	*2.1*			
grandis Lindl.	J723	Y	*4.2*	3.0	*1.8*			
lasiocarpa Hook.	J724	M	*2.7*	2.4	*1.3*			
Lowiana A. Murr.	J725	M	*3.9*	3.1	*1.9*			
magnifica A. Murr.	J62	M	*3.4*	2.5	*1.9*			
nobilis Lindl.	H726	O	*5.4*	4.4	*3.5*			
Nordmanniana Spach.						*1.0*	0.8	*0.6*
sibirica Ledeb.	J529	M	*3.5*	2.7	*1.7*			
venusta C. Koch.	J571	M	*4.0*	3.3	*1.3*			
Webbiana Lindl.	778	M	*4.1*	3.5	*2.8*			
Cedrus Deodara Loud.	789	O	*3.6*	2.9	*2.2*	*1.1*	0.8	*0.5*
Libani Barrel.	BM	O	*4.0*	3.0	*2.0*	*1.4*	0.8	*0.5*
Keteleeria Davidiana Beissn.	769	O	*5.6*	4.7	*2.2*	*1.8*	1.4	*1.1*
Larix dahurica Turcz.	J39	Y	*2.8*	2.4	*2.0*			
decidua Mill.	714	M	*4.9*	4.0	*3.3*	*1.2*	0.8	*0.5*
leptolepis Hort. ex Endl.	760	O	*5.3*	4.3	*3.3*	*1.1*	0.8	*0.4*
occidentalis Nutt.	J40	O	*5.6*	4.4	*1.9*			

TABLE I—*Continued.*

Designation		Older Wood				First Annual Ring.		
Plant	No.	Age*	Max.	Mean	Min.	Max.	Mean	Min.
Picea ajanensis Fisch.	J42	M	*4.6*	3.8	*2.5*			
alba Link.	H718	M	*4.4*	3.6	*2.7*			
Alcockiana Carr.	709	O	*5.3*	4.5	*3.1*			
canadensis Britton.	J43	M	*4.1*	3.4	*2.9*	*1.5*	1.0	*0.6*
Engelmanni Engelm.	J44	O	*4.1*	3.1	*1.5*			
excelsa Link.	J45	M	*2.4*	1.9	*1.5*	*1.1*	0.8	*0.5*
Mariana Britton.	J47	O	*3.9*	3.4	*2.7*	*0.9*	0.6	*0.4*
Morinda Link.	768	O	*5.2*	4.4	*3.3*			
obovata Ledeb.	J46	M	*4.1*	3.1	*2.0*			
polita Carr.	C46	M	*2.6*	1.9	*1.7*			
pungens Engelm.	J533	M	*3.4*	2.8	*1.8*			
rubens Sarg.	J48	O	*3.2*	2.6	*1.6*			
sitchensis Trautv. & Mey.	J50	M	*6.8*	5.6	*4.5*			
Pinus albicaulis Engelm.	H537	M	*4.3*	3.1	*2.0*			
aristata Engelm.	J1	M	*2.4*	1.8	*1.0*			
arizonica Engelm.	J3	Y	*2.2*	1.9	*1.7*			
attenuata Lemmon.	H565	O	*3.5*	3.0	*1.9*			
Balfouriana S. Wats.	J5	O	*2.8*	2.4	*2.2*			
Bungeana Zucc.	1124	Y	*3.2*	2.4	*1.6*			
cembra Linn.	705	O	*2.6*	2.0	*1.2*			
cembroides Zucc.	J6	M	*3.2*	2.5	*1.5*			
Chihuahuana Engelm.	J7	O	*5.5*	4.9	*2.5*			
clausa Vasey.	J8	Y	*3.7*	3.0	*2.4*			

contorta Dougl.	H579	M	*3.7*	3.1	*2.6*	*1.3*	1.0	*0.7*
contorta var. *Murrayana* Engelm.	J22	M	*3.9*	2.9	*2.2*			
Coulteri D. Don.	J10	M	*3.1*	2.5	*1.4*			
cubensis Griseb.	J11	O	*6.0*	4.9	*3.5*			
densiflora Sieb. & Zucc.	C12	O	*5.6*	4.9	*3.9*			
divaricata Hort. ex Gord.	H714	Y	*2.6*	2.0	*1.3*			
edulis Engelm.	J14	O	*3.6*	2.9	*2.4*			
excelsa Wall.	641	M	*5.2*	4.3	*3.0*			
flexilis James.	J16	O	*3.8*	3.2	*2.9*	*1.1*	0.8	*0.5*
Gerardiana Wall.	750	O	*4.2*	3.8	*2.6*			
glabra Walt.	J17	M	*6.5*	5.3	*4.6*			
insularis Endl.	739	M	*5.2*	4.6	*2.9*			
Jeffreyi A. Murr.	J18	O	*5.9*	4.6	*3.6*			
Lambertiana Dougl.	J19	O	*5.5*	4.4	*2.7*			
Laricio Poir.	728	M	*4.5*	3.7	*2.6*			
longifolia Roxb.	746	M	*6.2*	4.5	*3.7*			
macrophylla Engelm.	J20		*5.0*	4.4	*4.0*			
Massoniana D. Don.	749	O	*5.7*	4.7	*3.5*			
Merkusii Jungh. & De Vriese.	741	M	*6.9*	5.2	*3.5*			
monophylla Torr. & Frém.	H566	O	*4.9*	3.1	*2.4*			
monticola Dougl.	H539	O	*6.0*	5.2	*3.9*			
muricata D. Don.	J21	M	*4.0*	3.2	*1.7*			
palustris Mill.	H526	M	*4.6*	3.6	*1.5*			
parviflora Sieb. & Zucc.	722	O	*5.9*	4.4	*3.0*			
ponderosa Dougl.	J26	O	*3.8*	3.3	*2.2*	*1.0*	0.8	*0.5*
Pumilio Haenke.	J24	Y	*2.4*	1.9	*1.3*			
pungens Lamb.	H575	M	*5.0*	4.0	*1.8*			
quadrifolia Parry.	H540	M	*4.0*	2.5	*1.4*			
reflexa Engelm.	J28	M	*4.0*	3.1	*1.3*			
resinosa Ait.	J29	M	*3.2*	2.7	*1.8*	*1.3*	1.0	*0.7*

TABLE I — *Continued.*

Designation		Older Wood				First Annual Ring.		
Plant	No.	Age*	Max.	Mean	Min.	Max.	Mean	Min.
Pinus rigida Mill.	J30	O	*5.3*	4.0	*3.2*			
Sabiniana Dougl.	J32	Y	*3.5*	2.9	*2.3*			
serotina Michx.	J33	M	*6.1*	4.5	*2.8*			
Strobus Linn.	J34	M	*5.0*	3.9	*2.3*	*1.1*	0.8	*0.6*
sylvestris Linn.	715	M	*3.9*	3.2	*2.2*	*1.0*	0.7	*0.5*
Taeda Linn.	J70	M	*7.3*	5.4	*3.6*	*1.7*	1.4	*0.9*
Thunbergii Parl.	708	M	*4.8*	3.6	*2.9*			
Torreyana Parry.	J35	M	*5.3*	3.9	*2.4*			
tuberculata Gord.	J37	M	*3.4*	3.0	*2.8*			
Pseudolarix Kaempferi Gord.						*1.2*	1.0	*0.5*
Pseudotsuga macrocarpa Lemmon.	762	M	*3.4*	3.1	*2.1*			
taxifolia Britton.	J54	M	*4.2*	2.6	*1.8*	*1.2*	0.8	*0.5*
Tsuga canadensis Carr.	SB	M	*4.3*	3.2	*1.9*			
caroliniana Engelm.	J51	M	*3.5*	3.1	*2.5*	*1.2*	0.9	*0.5*
formosana Hayata.	710	O	*5.4*	3.5	*1.4*			
Mertensiana Carr.	J53	O	*4.6*	3.7	*2.5*			
Sieboldii Carr.	699	O	*4.8*	4.0	*3.0*			
Taxodieae								
Athrotaxis selaginoides D. Don.						*1.4*	1.1	*0.9*
Cryptomeria japonica D. Don.	C41	O	*3.7*	2.7	*1.9*	*0.9*	0.7	*0.4*
Cunninghamia sinensis R. Br.						*1.5*	1.1	*0.6*
Glyptrostrobus heterophyllus Endl.						*1.4*	1.0	*0.6*
Sciadopitys verticillata Sieb. & Zucc.	759	O	*3.8*	3.2	*2.5*	*1.2*	0.9	*0.6*

Sequoia gigantea Lindl. & Gord.	J66	O	5.4	4.6	3.0			
Idem.	B14	O	4.1	2.9	2.1			
Idem.	J67	O	7.0	5.0	3.7			
sempervirens Endl.	B15	M	9.2	6.4	2.6	1.3	1.0	0.7
Idem.	B16	O	8.4	6.5	4.1			
Taiwania cryptomerioides Hayata.	721	M	6.7	5.7	5.1	1.4	1.1	0.7
Taxodium distichum Rich.	J65	M	5.6	4.1	1.5	1.1	0.8	0.6
Idem.	H727	O	7.8	6.5	3.5			
Cupresseae-Actinostrobinae.								
Actinostrobus pyramidalis Miq.						1.2	0.9	0.7
Callitris calcarata R. Br.	757	O	3.5	2.7	1.9	1.0	0.8	0.5
Cupresseae-Thujopsidinae.								
Libocedrus decurrens Torr.	J69	M	3.8	3.2	2.7	0.8	0.7	0.6
macrolepis Benth. & Hook.	763	O	4.4	3.5	2.3			
Thuja japonica Maxim.	698	O	4.1	3.4	2.8			
occidentalis Linn.	J71	M	2.9	2.2	1.3	0.9	0.7	0.6
plicata Donn.	J530	O	3.2	2.6	1.8			
Idem.	H728	O	4.0	3.2	2.0			
Idem.	B17	O	5.4	4.7	4.0			
Thujopsis dolabrata Hort.						1.3	0.9	0.7
Cupresseae-Cupressinae.								
Chamaecyparis formosensis Matsum.	752	O	4.9	3.7	2.7			
Lawsoniana Parl.	J76	O	4.1	3.4	2.7			
nootkatensis Lamb.	J77	O	3.2	2.8	2.2			
obtusa Sieb. & Zucc.	745	O	5.4	3.7	2.1			
thyoides Sarg.	J78	M	4.7	3.8	2.9	0.9	0.7	0.5
Cupressus arizonica Greene.	J561	M	2.1	1.5	1.1			
Goveniana Gord.	H559	M	3.3	2.6	2.0			
guadalupensis S. Wats.	702	O	2.4	2.1	1.7			
Macnabiana A. Murr.	J75	O	2.6	2.0	1.5	1.1	0.8	0.6
macrocarpa Hartw.	J74	M	3.8	3.2	2.8			

TABLE I — *Concluded.*

Designation		Older Wood				First Annual Ring		
Plant	No.	Age*	Max.	Mean	Min.	Max.	Mean	Min.
Juniperus barbadensis Linn.	J79	O	*3.2*	2.7	*1.7*			
bermudiana Linn.	J81	M	*3.7*	2.3	*1.4*			
californica Carr.	J83	O	*2.4*	2.0	*1.6*			
chinensis Linn.	C11	O	*2.0*	1.7	*1.2*			
macropoda Boiss.	720	O	*3.0*	2.6	*1.8*			
occidentalis Hook.	J84	O	*2.2*	1.8	*1.1*			
pachyphlaea Torr.	J86	O	*2.8*	2.2	*1.6*			
scopulorum Sarg.	J87	M	*2.7*	2.2	*1.5*			
virginiana Linn.	H732	M	*2.8*	2.0	*1.3*	*0.9*	0.6	*0.4*

TABLE II.

ANGIOSPERMAE-DICOTYLEDONEAE.

Secondary Xylem: Length of Tracheary Elements in Millimeters.

Designation				Older Wood						First Annual Ring	
		Type†	Age*	Vessel Segments			Other tracheary cells			Vessel segments	Other tracheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.	Mean	Mean
A. Archichlamydeae											
I. Verticillatae.											
1. Casuarinaceae.											
Casuarina torulosa Ait.	1481	II	O	*0.7*	0.6	*0.4*	*1.4*	1.0	*0.7*		
II. Piperales.											
2. Piperaceae.											
Cubeba officinalis Rafin.	1077	IV	Y	*0.4*	0.3	*0.2*	*0.6*	0.5	*0.4*		
Macropiper excelsum Miq.	665	IV	Y	*0.4*	0.2	*0.1*	*0.9*	0.7	*0.6*		
3. Chloranthaceae.											
Chloranthus officinalis Blume.	1092	I	Y	*1.1*	0.8	*0.4*	*1.2*	0.9	*0.6*		
III. Salicales.											
4. Salicaceae.											
Populus grandidentata Michx.	J135	III	M	*0.9*	0.7	*0.5*	*1.5*	1.3	*1.0*	0.4	0.5
Salix alba Linn.	584	IV	M	*0.6*	0.5	*0.4*	*1.2*	0.9	*0.7*		

* Y = less than 15 years from pith. O = more than 30 years from pith. M = 15–30 years from pith.
† See page 190.

TABLE II—*Continued.*

Designation		Older Wood								First Annual Ring	
Plant	No.	Type	Age	Vessel Segments			Other tracheary cells			Vessel segments	Other tracheary cells
				Max.	Mean	Min.	Max.	Mean	Min.	Mean	Mean
IV. Myricales.											
5. Myricaceae.											
Myrica californica Cham. & Schlecht.	J106	I	M	*0.9*	0.7	*0.5*	*1.3*	1.0	*0.8*		
V. Leitneriales.											
6. Leitneriaceae.											
Leitneria floridana Chapm.	361	IV	M	*0.8*	0.6	*0.5*	*1.1*	0.7	*0.5*		
VI. Juglandales.											
7. Juglandaceae.											
Carya ovata (Mill) K. Koch.	PB	IV	O	*0.6*	0.5	*0.4*	*1.5*	1.1	*0.8*	0.3	0.7
Engelhardtia spicata Blume.	279	IV	O	*0.9*	0.7	*0.5*	*1.8*	1.5	*1.2*		
Juglans cinerea Linn.	J513	IV	O	*0.6*	0.4	*0.3*	*1.6*	1.1	*0.8*		
VII. Fagales.											
8. Betulaceae.											
Alnus rubra Bongard.	J149	I	O	*0.9*	0.8	*0.6*	*1.4*	1.1	*1.0*	0.6	0.7
Betula lutea Michx.	J139	I	O	*1.5*	1.2	*0.9*	*2.1*	1.7	*1.1*		
Corylus rostrata Ait.	J507	I	Y	*0.7*	0.5	*0.4*	*1.1*	0.9	*0.7*	0.5	0.7
9. Fagaceae.											
Castanea vesca Gaertn.	240	IV	O	*0.8*	0.7	*0.5*	*1.2*	1.0	*0.7*	0.3	0.5
Fagus ferruginea Ait.	J153	IV	O	*0.7*	0.6	*0.4*	*1.4*	1.2	*0.9*	0.3	0.6
Quercus Kelloggii Newberry.	J187	IV	O	*0.6*	0.5	*0.4*	*1.5*	1.0	*0.7*	0.5	0.7

VIII. Urticales.											
10. Ulmaceae.											
Holoptelea integrifolia Planch.	618	IV	O	*0.4*	0.3	*0.2*	*1.2*	1.0	*0.8*		
Planera aquatica J. F. Gmel.	J203	IV	M	*0.3*	0.2	*0.2*	*1.5*	1.2	*.9*		
Ulmus americana Linn.	610	IV	O	*0.3*	0.2	*0.1*	*1.3*	1.1	*0.8*	0.2	0.4
Zelkova acuminata Planch.	619	IV	O	*0.3*	0.2	*0.2*	*2.3*	1.9	*1.6*		
11. Moraceae.											
Artocarpus incisa Linn. f.	925	IV	Y	*0.7*	0.6	*0.5*	*2.1*	1.9	*1.5*		
Castilloa fallax O. F. Cook.	1594	IV	M	*0.5*	0.4	*0.3*	*1.5*	1.1	*0.8*		
Morus alba Linn.	H643	IV	M	*0.3*	0.2	*0.2*	*1.2*	0.8	*0.7*	0.2	0.4
12. Urticaceae.											
Boehmeria rugulosa Wedd.	1002	IV	O	*0.5*	0.3	*0.2*	*2.0*	1.4	*0.8*		
Neraudia melastomaefolia Mus. Par. ex Blume.	943	III	M	*1.1*	1.0	*0.8*	*1.7*	1.5	*1.1*		
Pipturus albidus A. Gray.	940	IV	M	*0.4*	0.2	*0.1*	*1.1*	0.9	*0.6*		
IX. Proteales.											
13. Proteaceae.											
Banksia verticillata R. Br.	496	IV	M	*0.5*	0.4	*0.3*	*1.8*	1.5	*1.0*		
Grevillea robusta A. Cunn.	498	IV	M	*0.5*	0.4	*0.3*	*2.1*	1.6	*1.0*		
Hakea leucoptera R. Br.	499	IV	M	*0.4*	0.3	*0.2*	*1.8*	1.5	*1.1*		
X. Santalales.											
14. Santalaceae.											
Santalum ellipticum Gaudich.	914	IV	M	*0.4*	0.3	*0.2*	*1.1*	1.0	*0.7*		
Cygnorum Miq.	569	IV	M	*0.4*	0.2	*0.1*	*0.8*	0.5	*0.3*		
15. Olacaceae.											
Olax imbricata Roxb.	1091	IV	Y	*0.5*	0.3	*0.2*	*1.3*	1.0	*0.8*		
15a. Loranthaceae											
Tupeia antarctica Cham. & Schlecht.	1173	IV	Y	*0.1*	0.1	*0.1*	*0.5*	0.4	*0.2*		
XI. Aristolochiales.											
16. Aristolochiaceae.											
Aristolochia tricaudata Lem.	1039	IV	Y	*0.4*	0.3	*0.2*	*1.1*	1.0	*0.8*		
tomentosa Sims.	666	IV	Y	*0.3*	0.2	*0.2*	*0.7*	0.6	*0.4*		

TABLE II —*Continued.*

Designation				Older Wood						First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells			Vessel segments	Other tracheary cells
Plant	No.			*Max.*	*Mean*	*Min.*	*Max.*	*Mean*	*Min.*	*Mean*	*Mean*
XII. Polygonales.											
17. Polygonaceae.											
Coccoloba uvifera Linn.	J215	IV	M	*0.4*	0.4	*0.3*	*0.9*	0.7	*0.4*	0.3	0.4
XIII. Centrospermae.											
18. Chenopodiaceae.											
Atriplex species.	828	IV	M	*0.1*	0.1	*0.1*	*0.4*	0.3	*0.2*		
Kochia pyramidata Benth.	1340	IV	M	*0.1*	0.1	*0.1*	*0.4*	0.3	*0.2*		
Suaeda fruticosa Hook & Arn.	1075	IV	M	*0.1*	0.1	*0.1*	*0.4*	0.3	*0.2*		
19. Amarantaceae.											
Charpentiera ovata Gaudich.	1000	IV	M	*0.3*	0.3	*0.2*	*1.1*	0.8	*0.5*	0.2	0.3
Nototrichum sandwicense Hillebr.	995	IV	O	*0.2*	0.1	*0.1*	*0.6*	0.5	*0.4*		
20. Nyctaginaceae.											
Pisonia obtusata Jacq.	J95	IV	O	*0.1*	0.1	*0.1*	*0.8*	0.6	*0.4*		
21. Phytolaccaceae.											
Seguieria Langsdorffii Moq.	1568	IV	O	*0.4*	0.3	*0.2*	*1.2*	0.9	*0.7*		
XIV. Ranales.											
22. Trochodendraceae.											
Trochodendron aralioides Sieb. & Zucc.	1765		O				*6.0*	4.5	*2.8*		2.2
23. Cercidiphyllaceae.											

Cercidiphyllum japonicum Sieb. & Zucc.	607	I	O	*2.0*	1.6	*1.4*	*2.2*	1.9	*1.4*	0.7	0.7+
24. Ranunculaceae.											
Clematis indivisa Willd.	1160	IV	M	*0.5*	0.4	*0.2*	*0.7*	0.5	*0.4*		
Paeonia Moutan Sims	771	I	M	*0.4*	0.3	*0.2*	*0.6*	0.4	*0.3*		
25. Berberidaceae.											
Berberis Fremontii Torr.	J497	IV	M	*0.3*	0.2	*0.1*	*0.5*	0.4	*0.3*		
26. Menispermaceae.											
Sarcopetalum tomentosum Hook. f. & Thoms.	489	IV	M	*0.5*	0.4	*0.2*	*1.3*	1.1	*0.8*		
27. Magnoliaceae.											
Drimys Winteri Forst.	B18		O				*5.1*	4.3	*3.5*		1.6
Illicium anisatum Gaertn.	1668	I								0.8	0.9
Kadsura scandens Blume.	1514	II	Y		1.1			1.6			
Liriodendron tulipifera Linn.	1658	I	O	*1.5*	1.1	*0.7*	*2.8*	2.3	*1.7*	0.5	0.6
Magnolia acuminata Linn.	1653	II	O	*1.1*	0.8	*0.6*	*2.1*	1.6	*0.9*	0.6	0.8
Michelia Champaca Linn.	477	I	O	*1.2*	0.8	*0.7*	*1.8*	1.4	*0.8*		
Tetracentron sinense Oliver.	1500										1.8
28. Anonaceae.											
Anona laurifolia Dunal.	4	IV	M	*0.5*	0.4	*0.3*	*1.5*	1.3	*0.7*		
Cyathocalyx globosus Merrill.	8	IV	O	*0.8*	0.6	*0.3*	*2.0*	1.5	*1.4*		
Polyalthia flava Merrill.	6	IV	O	*0.4*	0.3	*0.2*	*1.6*	1.2	*0.8*		
29. Myristicaceae.											
Myristica philippensis Lam.	487	I	O	*1.6*	1.2	*0.7*	*1.7*	1.4	*1.1*		
Virola species.	1622	II	M		1.0			1.5			
30. Monimiaceae.											
Doryphora Sassafras Endl.	481	I	O		1.0			1.6		0.5	0.8
Hedycarya arborea Forst.	480	I	O		1.5			1.8			
Laurelia Novae-Zelandiae A. Cunn.	479	I	O		1.4			1.6		0.9	1.0
31. Lauraceae.											
Beilschmiedia Cairocan Vidal.	343	IV	O	*0.9*	0.8	*0.7*	*2.0*	1.6	*1.3*		

TABLE II—*Continued.*

Designation				Older Wood						First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells			Vessel segments	Other tracheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.	Mean	Mean
Cryptocarya Mannii Hillebr.	966	IV	M	*0.6*	0.5	*0.4*	*1.3*	1.1	*0.9*		
Sassafras officinale Nees & Eberm.	NN	IV	O	*0.5*	0.4	*0.3*	*1.1*	0.8	*0.7*	0.3	0.4
32. Hernandiaceae.											
Gyrocarpus americanus Jacq.	272	IV	O	*0.5*	0.3	*0.2*	*1.2*	1.0	*0.6*		
Jacquini Gaertn.	273	IV	O	*0.5*	0.4	*0.2*	*1.0*	0.9	*0.7*		
XV. Rhoeadales.											
33. Papaveraceae.											
Dendromecon rigidum Benth.	680	IV	Y	*0.6*	0.4	*0.2*	*0.7*	0.6	*0.4*		
34. Capparidaceae.											
Capparis jamaicensis Jacq.	J104	IV	O	*0.3*	0.2	*0.1*	*0.6*	0.2	*0.3*	0.2	0.2+
Crataeva Tapia Linn.	1561	IV	M	*0.4*	0.3	*0.2*	*1.0*	0.8	*0.7*		
XVI. Rosales.											
35. Saxifragaceae.											
Brexia serrata Presl.	1066	III	M	*0.8*	0.6	*0.4*	*1.2*	1.0	*0.7*		
Ceratopetalum apetalum D. Don.	566	II	O	*1.1*	0.9	*0.6*	*1.4*	1.3	*0.9*		
Hydrangea quercifolia Bartram.	J234	I	Y	*1.6*	1.1	*0.7*	*2.0*	1.6	*1.0*		
36. Pittosporaceae.											
Pittosporum bicolor Hook.	1419	III	M	*0.6*	0.5	*0.3*	*0.9*	0.8	*0.6*		
Buchanani Hook. f.	507	III	M	*0.8*	0.7	*0.4*	*1.0*	0.8	*0.6*		
cornifolium A. Cunn.	1151	III	M	*0.6*	0.5	*0.4*	*0.8*	0.7	*0.6*		

37. Cunoniaceae.											
Weinmannia racemosa Linn.	567	I	O	*1.2*	0.8	*0.6*	*1.2*	1.0	*0.8*		
rubifolia Benth.	568	IV	O	*0.7*	0.6	*0.5*	*1.5*	1.3	*1.1*		
38. Hamamelidaceae.											
Altingia excelsa Noronha.	875	I	O	*2.3*	1.9	*1.2*	*3.1*	2.8	*2.0*	0.7	1.0
Bucklandia populnea R. Br.	880	I	O	*2.4*	1.6	*1.2*	*3.2*	2.7	*1.6*	0.8	1.0
Distylium species	773	I	O	*1.2*	0.9	*0.7*	*1.7*	1.4	*1.0*		
Hamamelis virginiana Linn.	J235	I	O	*1.1*	0.8	*0.5*	*1.6*	1.1	*0.8*	0.5	0.6
39. Platanaceae.											
Platanus occidentalis Linn.	N825	II	O	*0.8*	0.5	*0.3*	*1.9*	1.6	*1.0*	0.3	0.7
40. Rosaceae.											
Crataegus cordata Ait.	J251	IV	M	*0.6*	0.5	*0.2*	*1.3*	1.0	*0.8*		
Prunus serotina Ehrh.	J269	IV	O	*0.6*	0.5	*0.4*	*1.8*	1.4	*1.1*	0.3	0.4
Pygeum Preslii Merrill.	518	IV	O	*0.7*	0.5	*0.4*	*1.8*	1.4	*0.9*		
41. Leguminosae.											
Bauhinia purpurea Linn.	1363	IV	O	*0.3*	0.3	*0.2*	*1.6*	1.2	*1.1*		
Cercis canadensis Linn.	J286	IV	O	*0.3*	0.2	*0.2*	*1.4*	1.0	*0.7*	0.2	0.4
Wallaceodendron celebicum Koord.	341	IV	O	*0.5*	0.4	*0.3*	*1.4*	1.1	*0.8*		
XVII. Geraniales.											
42. Oxalidaceae.											
Averrhoa Species.	1105	IV	M	*0.4*	0.3	*0.2*	*0.6*	0.5	*0.4*		
43. Erythroxylaceae.											
Erythroxylum monogynum Roxb.	175	IV	M	*0.7*	0.4	*0.2*	*1.4*	1.1	*0.9*		
44. Zygophyllaceae.											
Larrea mexicana Moric.	J108	IV	M	*0.3*	0.2	*0.2*	*0.8*	0.6	*0.5*	0.2	0.4
Guaiacum officinale Linn.	1032	IV	O	*0.2*	0.1	*0.1*	*0.7*	0.5	*0.3*		
45. Rutaceae.											
Platydesma campanulata H. Mann.	923	III	M	*0.7*	0.5	*0.3*	*1.2*	1.0	*0.7*		
Ptelea trifoliata Linn.	J312	IV	M	*0.4*	0.2	*0.1*	*1.0*	0.8	*0.5*		
Xanthoxylum Species.	1613	IV	M	*0.7*	0.6	*0.5*	*1.6*	1.2	*0.7*		

TABLE II—*Continued.*

Designation		Older Wood									First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells				Vessel seg-ments	Other tra-cheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.		Mean	Mean
46. Simarubaceae.												
Ailanthus philippinensis Merrill.	583	IV	O	*0.6*	0.5	*0.3*	*1.6*	1.3	*1.0*			
Simaruba glauca DC.	J315	IV	O	*0.7*	0.6	*0.5*	*1.1*	1.0	*0.7*		0.3	0.6
47. Burseraceae.												
Bursera Simaruba Sarg.	J101	IV	M	*0.8*	0.5	*0.4*	*1.3*	1.0	*0.6*		0.3	0.4
Canarium ovatum Engl.	50	IV	O	*0.8*	0.6	*0.4*	*1.6*	1.3	*1.0*			
48. Meliaceae.												
Aglaia Clarkii Merrill.	442	IV	O	*0.8*	0.6	*0.4*	*1.6*	1.3	*0.9*			
Swietenia Mahogoni Jacq.	J319	IV	M	*0.5*	0.4	*0.3*	*1.3*	1.0	*0.7*		0.3	0.4
Xylocarpus obovatus A. Juss.	457	IV	O	*0.4*	0.3	*0.2*	*1.1*	0.9	*0.8*			
49. Malpighiaceae.												
Byrsonima Cumingana A. Juss.	1650	III	M	*0.8*	0.7	*0.4*	*1.9*	1.6	*1.0*			
50. Polygalaceae.												
Xanthophyllum flavescens Roxb.	512	IV	O	*0.8*	0.5	*0.3*	*1.0*	0.8	*0.4*			
species.	511	IV	M	*0.8*	0.5	*0.3*	*1.3*	1.1	*0.8*			
51. Euphorbiaceae.												
Antidesma edule Merrill.	159	IV	M	*1.0*	0.8	*0.5*	*1.8*	1.4	*1.0*		0.5	0.8
Aporosa sympocosifolia Merrill.	158	IV	M	*1.1*	0.9	*0.6*	*2.9*	2.1	*1.3*			
Ricinus communis Linn.	H644	IV	M	*0.7*	0.5	*0.4*	*1.4*	1.1	*0.7*			
Sapium jamaicense Sw.	1627	IV	M	*0.9*	0.7	*0.4*	*1.5*	1.3	*0.8*			

XVIII. Sapindales.											
52. Coriariaceae.											
Coriaria ruscifolia Linn.	88	IV	M	*0.3*	0.2	*0.2*	*1.0*	0.8	*0.6*		
53. Anacardiaceae.											
Dracontomelon Cumingianum Baill.	16	IV	O	*0.9*	0.8	*0.6*	*1.6*	1.4	*1.1*		
Rhus typhina Linn.	J334	IV	M	*0.3*	0.2	*0.1*	*0.8*	0.6	*0.4*	0.2	0.3
Spondias mangifera Willd.	821	IV	O	*0.6*	0.5	*0.4*	*1.4*	1.0	*0.7*		
54. Cyrillaceae.											
Cliftonia monophylla Britton.	J339	I	O	*1.0*	0.8	*0.6*	*1.3*	1.0	*0.6*		
Cyrilla racemiflora Linn.	J338	I	O	*0.9*	0.8	*0.6*	*1.1*	1.0	*0.9*		
55. Aquifoliaceae.											
Byronia sandwicensis Endl.	959	I	O	*1.6*	1.3	*1.1*	*2.6*	2.0	*1.5*	0.7	1.0
Ilex opaca Ait.	N797	I	O	*1.0*	0.9	*0.8*	*1.8*	1.3	*0.9*	0.6	0.7
56. Celastraceae.											
Euonymus atropurpureus Jacq.	J348	IV	M	*0.8*	0.6	*0.4*	*0.9*	0.8	*0.7*		
Lophopetalum Wallichii Kurz.	182	IV	M	*1.4*	0.9	*0.4*	*1.9*	1.6	*0.9*		
Perrottetia sandwicensis A. Gray.	928	I	M	*1.1*	1.0	*0.8*	*1.5*	1.2	*0.7*	0.8	0.9
57. Salvadoraceae.											
Salvadora oleoides Decne.	556	IV	O	*0.2*	0.2	*0.1*	*0.8*	0.6	*0.4*		
58. Staphyleaceae.											
Turpinia nepalensis Wall.	564	I	O	*2.1*	1.4	*0.9*	*2.5*	1.9	*1.1*	0.9	1.0
59. Icacinaceae.											
Gonocaryum species.	276	III	O	*1.1*	0.8	*0.6*	*2.8*	2.4	*2.0*		
Pennantia corymbosa Forst.	277	III	O	*0.8*	0.7	*0.5*	*1.3*	1.0	*0.7*		
Stemonurus secundiflorus Blume.	1101	I	Y	*1.9*	1.6	*1.3*	*2.4*	2.0	*1.6*	0.8	1.2
Urandra luzoniensis Merrill.	278	I	O	*1.7*	1.4	*1.1*	*3.7*	3.3	*2.7*	0.9	1.1
Villaresia Moorei F. Muell.	494	I	O	*2.0*	1.6	*1.0*	*3.4*	2.9	*2.6*		
60. Aceraceae.											
Acer saccharinum Wangenh.	J358	IV	O	*0.5*	0.4	*0.3*	*0.8*	0.6	*0.5*	0. 2	0.4
61. Hippocastanaceae.											
Aesculus glabra Willd.	J366	IV	O	*0.5*	0.4	*0.3*	*1.1*	0.9	*0.7*	0.3	0.5

TABLE II—*Continued.*

Designation		Older Wood									First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells				Vessel seg-ments	Other tra-cheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.		Mean	Mean
62. Sapindaceae.												
Dodonaea viscosa Jacq.	921	IV	M	*0.4*	0.3	*0.2*	*1.0*	0.9	*0.7*		0.2	0.4
Pometia pinnata Forst.	562	IV	O	*0.5*	0.4	*0.2*	*1.2*	0.9	*0.7*			
Sapindus marginatus Willd.	J372	IV	O	*0.3*	0.2	*0.2*	*1.7*	1.2	*0.6*			
63. Sabiaceae.												
Meliosma Arnottiana Walp.	551	I	O	*1.3*	1.2	*1.0*	*2.1*	1.5	*1.1*			
XIX. Rhamnales.												
64. Rhamnaceae.												
Rhamnus cathartica Linn.	J383	IV	O	*0.4*	0.3	*0.2*	*0.9*	0.7	*0.4*		0.3	0.4
Zizyphus zonulatus Blanco.	546	IV	O	*1.0*	0.7	*0.4*	*1.3*	1.1	*0.8*			
65. Vitaceae.												
Leea aculeata Blume.	1103	II	Y	*1.0*	0.8	*0.5*	*2.0*	1.4	*0.9*			
Vitis californica Benth.	J510	IV	M	*0.9*	0.7	*0.6*	*1.1*	0.9	*0.6*			
XX. Malvales.												
66. Elaeocarpaceae.												
Echinocarpus dasycarpus Benth.	149	III	M	*1.1*	1.0	*0.8*	*1.7*	1.4	*1.2*		0.4	0.5
Elaeocarpus bifida Hook. & Arn.	918	III	O	*1.0*	0.9	*0.7*	*1.4*	1.2	*1.0*			
Muntingia Calabura Linn.	156	IV	M	*0.4*	0.3	*0.2*	*1.8*	1.3	*1.0*			
Sloanea species.	1556	IV	M	*1.0*	0.8	*0.7*	*1.5*	1.2	*1.0*			

67. Tiliaceae.											
Grewia stylocarpa Warb.	601	III	M	*0.8*	0.7	*0.6*	*2.0*	1.6	*1.4*		
Tilia americana Linn.	N840	IV	O	*0.5*	0.4	*0.3*	*1.5*	1.1	*0.8*	0.3	0.7
68. Malvaceae.											
Bombycidendron Vidalianum Merrill. & Rolfe	474	IV	O	*0.4*	0.3	*0.2*	*2.0*	1.7	*0.8*		
Gossypium drynarioides Seem.	926	IV	M	*0.4*	0.3	*0.2*	*1.0*	0.7	*0.5*		
Thespesia populnea Soland.	471	IV	O	*0.4*	0.3	*0.2*	*1.6*	1.2	*0.9*		
69. Bombacaceae.											
Bombax malabaricum DC.	40	IV	O	*0.5*	0.4	*0.3*	*2.0*	1.6	*1.2*		
Cumingia philippinensis Vidal.	41	IV	O	*0.4*	0.4	*0.3*	*0.9*	0.8	*0.6*		
Ochroma Lagopus Sw.	1485	IV	O	*0.6*	0.4	*0.2*	*1.4*	1.0	*0.7*		
70. Sterculiaceae.											
Fremontia californica Torr.	J100	IV	O	*0.3*	0.2	*0.1*	*1.7*	1.6	*1.5*		
Heritiera littoralis Ait.	588	IV	M	*0.4*	0.3	*0.2*	*1.8*	1.4	*1.0*		
Kleinhovia Hospita Linn.	589	IV	O	*0.5*	0.4	*0.3*	*1.3*	1.0	*0.8*		
Sterculia crassiramea Merrill.	594	IV	O	*0.6*	0.5	*0.3*	*2.5*	1.9	*1.1*		
XXI. Parietales.											
71. Dilleniaceae.											
Curatella americana Linn.	1599	II	M	*1.0*	0.7	*0.5*	*2.4*	2.1	*1.4*		
Dillenia pentagyna Roxb.	102	I	M	*1.6*	1.2	*0.9*	*2.7*	2.1	*1.2*		
philippinensis Rolfe.	101	I	O	*2.3*	1.6	*1.0*	*3.4*	2.8	*2.2*	0.9	1.3
Saurauja Oldhami Hemsl.	105	I	M	*2.4*	2.0	*1.6*	*3.4*	2.9	*2.7*	1.3	1.6
Wormia excelsa Jack.	1059	I	Y	*2.3*	1.6	*0.7*	*3.0*	2.6	*2.0*	0.8	1.3
72. Ochnaceae.											
Cespedesia macrophylla Seem.	1640	IV	O	*0.7*	0.5	*0.4*	*1.4*	1.2	*1.0*		
73. Theaceae.											
Gordonia Lasianthus Linn.	J324	I	O	*1.7*	1.3	*1.0*	*1.8*	1.6	*1.2*	0.8	0.9
Schima Wallichii Choisy.	998	I	O	*1.6*	1.4	*1.2*	*2.9*	2.3	*1.6*	0.9	1.0
Ternstroemia japonica Thunb.	609	I	O	*1.5*	1.2	*0.9*	*2.4*	1.8	*1.4*	0.8	0.9
Thea japonica Baill.	1236	I	O	*0.9*	0.7	*0.6*	*2.0*	1.7	*1.0*	0.6	0.8

TABLE II—*Continued.*

Designation		Older Wood									First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells				Vessel segments	Other tracheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.		Mean	Mean
74. Guttiferae.												
Calophyllum Inophyllum Linn.	889	IV	M	*0.8*	0.6	*0.4*	*1.4*	1.2	*0.9*			
Cratoxylon floribundum F. Vill.	191	IV	M	*0.4*	0.4	*0.2*	*1.2*	1.1	*0.9*			
Kayea paniculata Merrill.	192	IV	O	*1.1*	0.8	*0.5*	*1.7*	1.3	*0.9*			
Symphoria globulifera Linn.	1572	IV	M	*0.8*	0.6	*0.4*	*1.9*	1.7	*1.4*			
75. Dipterocarpaceae.												
Dipterocarpus affinis Brandis.	112	IV	O	*0.9*	0.7	*0.5*	*2.1*	1.8	*1.4*			
Hopea acuminata Merrill.	114	IV	O	*0.5*	0.4	*0.3*	*1.9*	1.5	*1.0*		0.2	0.4
Shorea species.	123	IV	O	*0.6*	0.4	*0.3*	*1.5*	1.2	*0.9*			
76. Tamaricaceae.												
Tamarix articulata Vahl.	1072	IV	M	*0.2*	0.2	*0.1*	*1.0*	0.9	*0.6*			
77. Fouquieraceae.												
Fouquieria splendens Engelm.	856	IV	M	*0.4*	0.3	*0.2*	*1.4*	1.1	*0.7*			
78. Cistaceae.												
Cistus monspeliensis Linn.	1171	IV	M	*0.5*	0.3	*0.2*	*0.6*	0.4	*0.3*			
79. Winteranaceae.												
Canella Winterana Gaertn.	J99	I	O	*1.5*	1.2	*1.0*	*1.9*	1.5	*1.0*			
80. Violaceae.												
Alsodeia Roxburghii Hook. f. & Thoms.	1055	II	Y	*0.9*	0.8	*0.6*	*1.4*	1.0	*0.8*			

Hymenanthera Banksii F. Muell.	1422	III	Y	*0.5*	0.4	*0.2*	*0.7*	0.5	*0.4*		
Melicytus ramiflorus Forst.	636	II	Y	*1.1*	0.9	*0.6*	*1.6*	1.2	*0.9*		
81. Flacourtiaceae.											
Casearia glomerata Roxb.	181	III	O	*1.2*	1.0	*0.9*	*1.9*	1.6	*1.2*	0.8	1.1
Homalium luzoniense F. Villar.	178	III	M	*1.3*	1.1	*0.9*	*2.1*	1.6	*1.1*	0.5	0.6
Myroxylon species.	957	III	O	*1.4*	1.0	*0.8*	*2.0*	1.7	*1.3*		
XXII. Opuntiales.											
82. Cactaceae.											
Cereus giganteus Engelm.	J401	IV	M	*0.7*	0.5	*0.4*	*1.1*	0.8	*0.5*		
Opuntia echinocarpa Engelm. & Bigel.	J402	IV	M	*0.2*	0.1	*0.1*	*0.5*	0.4	*0.3*		
XXIII. Myrtiflorae.											
83. Thymelaeaceae.											
Aquilaria Agallocha Roxb.	608	IV	O	*0.5*	0.4	*0.3*	*1.1*	0.9	*0.7*		
Wikstroemia sandwichensis Meissn.	920	IV	M	*0.3*	0.2	*0.1*	*0.9*	0.7	*0.4*		
84. Lythraceae.											
Adenaria floribunda H. B. & K.	1601	IV	O	*0.6*	0.3	*0.2*	*1.0*	0.8	*0.6*		
Lafoensia punicaeafolia DC.	1600	IV	M	*0.5*	0.5	*0.4*	*1.5*	1.0	*0.7*		
Lagerstroemia reginae Roxb.	847	IV	M	*0.5*	0.4	*0.3*	*1.5*	1.2	*0.6*		
85. Sonneratiaceae.											
Sonneratia acida Linn.	904	IV	O	*0.8*	0.5	*0.2*	*1.2*	1.0	*0.6*	0.3	0.4
86. Lecythidaceae.											
Barringtonia species.	280	IV	O	*0.7*	0.5	*0.3*	*2.0*	1.6	*1.0*		
Eschweilera species.	1620	IV	M	*0.7*	0.5	*0.4*	*1.6*	1.3	*1.1*		
species.	1621	IV	O	*0.6*	0.4	*0.3*	*1.5*	1.3	*0.9*		
87. Rhizophoraceae.											
Bruguiera gymnorrhiza Lam.	548	I	M	*1.2*	1.0	*0.7*	*2.1*	1.7	*1.3*		
Carallia integerrima DC.	550	III	O	*1.3*	1.1	*0.8*	*3.1*	2.6	*2.2*		
Cassipourea elliptica Poir.	1585	II	O	*1.5*	1.0	*0.8*	*2.0*	1.6	*1.2*		
Rhizophora Mangle Linn.	J118	I	O	*1.1*	0.8	*0.5*	*1.7*	1.4	*0.9*		
88. Nyssaceae.											
Nyssa aquatica Linn.	J419	I	M	*1.4*	1.1	*0.7*	*1.7*	1.4	*1.2*	0.7	1.0

TABLE II—*Continued.*

Designation		Older Wood								First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells			Vessel seg-ments	Other tra-cheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.	Mean	Mean
89. Alangiaceae.											
Alangium Lamarckii Thw.	89	III	O	*0.8*	0.6	*0.4*	*1.7*	1.5	*1.2*		
90. Combretaceae.											
Anogeissus latifolia Wall.	846	IV	O	*0.6*	0.4	*0.3*	*1.6*	1.3	*1.1*	0.2	0.4
Lumnitzera littorea Voigt.	61	III	M	*0.8*	0.5	*0.3*	*1.8*	1.5	*0.9*		
Terminalia alata D. Dietr.	873	IV	O	*0.6*	0.4	*0.2*	*1.6*	1.1	*0.9*		
edulis F. Muell.	68	III	M	*0.7*	0.5	*0.4*	*1.6*	1.3	*0.9*		
91. Myrtaceae.											
Eucalyptus rostrata Schlecht.	378	IV	M	*0.4*	0.3	*0.2*	*0.8*	0.7	*0.5*	0.3	0.4
Eugenia perpallida Merrill.	410	IV	M	*1.0*	0.6	*0.3*	*1.8*	1.5	*1.1*		
Metrosideros polymorpha Gaudich.	927	IV	M	*1.0*	0.8	*0.5*	*2.0*	1.7	*1.2*		
92. Melastomataceae.											
Memecylon edule Roxb.	486	IV	M	*0.4*	0.3	*0.2*	*1.1*	0.8	*0.7*		
Miconia species.	1609	IV	M	*0.7*	0.5	*0.3*	*0.8*	0.6	*0.3*		
Tibouchina mutabilis Cogn.	1612	IV	M	*0.6*	0.5	*0.4*	*1.0*	0.8	*0.6*		
93. Oenotheraceae.											
Fuchsia excorticata Linn. f.	495	IV	M	*0.4*	0.3	*0.2*	*0.9*	0.7	*0.4*		
XXIV. Umbelliflorae.											
94. Araliaceae.											
Aralia spinosa Linn.	J683	IV	M	*0.6*	0.4	*0.2*	*1.0*	0.7	*0.5*	0.4	0.5

Cheirodendron Gaudichaudii Seem.	947	II	M	*1.5*	1.2	*0.8*	*1.6*	1.4	*1.0*	0.6	0.8
platyphylla Seem.	917	II	M	*1.1*	1.0	*0.6*	*1.6*	1.3	*1.0*	0.6	0.7
Polyscias nodosa Seem.	30	II	O	*1.1*	1.0	*0.7*	*1.4*	1.3	*1.0*	0.6	0.8
95. Cornaceae.											
Cornus florida Linn.	J412	I	O	*1.4*	1.1	*0.8*	*2.0*	1.7	*1.4*	0.6	0.8
Corokia Cotoneaster Raoul.	97	I	M	*1.3*	0.7	*0.4*	*0.9*	0.8	*0.7*		
Daphniphyllopsis capitata Kurz.	862	I	O	*2.2*	1.7	*1.1*	*3.1*	2.6	*1.7*		
Griselinia lucida Forst. f.	98	I	M	*2.2*	1.9	*1.6*	*2.3*	2.1	*1.6*		
B. METACHLAMYDEAE.											
XXV. Ericales.											
96. Clethraceae.											
Clethra alnifolia Linn.	801	I	Y	*1.1*	0.8	*0.5*	*1.1*	0.9	*0.7*		
97. Ericaceae.											
Andromeda ferruginea Walt.	J427	I	O	*1.0*	0.8	*0.6*	*1.4*	1.1	*0.9*		
Arbutus Menziesii Pursh.	J423	II	O	*0.7*	0.5	*0.4*	*0.9*	0.7	*0.5*		
Arctostaphylos tomentosa Lindl.	J437	II	M	*0.5*	0.4	*0.2*	*0.7*	0.6	*0.4*		
Kalmia latifolia Linn.	J430	I	O	*0.9*	0.8	*0.7*	*1.1*	1.0	*0.8*	0.4	0.5
Oxydendrum arboreum DC.	J429	II	O	*0.7*	0.5	*0.4*	*1.1*	0.9	*0.7*		
Rhododendron catawbiense Michx.	J432	I	O	*0.5*	0.4	*0.2*	*0.7*	0.5	*0.4*		
Vaccinium arboreum Marsh.	J420	I	O	*0.5*	0.4	*0.3*	*0.9*	0.7	*0.6*		
corymbosum Linn.	J421	II	O	*0.6*	0.4	*0.3*	*0.9*	0.8	*0.6*		
98. Epacridaceae.											
Dracophyllum latifolium A. Cunn.	1450	I	Y	*0.6*	0.4	*0.2*	*0.8*	0.5	*0.3*	0.4	0.5
XXVI. Primulales.											
99. Myrsinaceae.											
Ardisia Pickeringia Torr. & Gray.	J439	IV	O	*0.5*	0.4	*0.3*	*1.1*	0.9	*0.7*	0.3	0.4
Myrsine Rapanea Roem. & Schult.	J441	IV	M	*0.7*	0.5	*0.4*	*1.2*	0.9	*0.7*		
Suttonia Lessertiana Mez.	933	IV	M	*0.6*	0.5	*0.4*	*1.1*	0.8	*0.5*		
XXVII. Ebenales.											
100. Sapotaceae.											
Bumelia cuneata Sw.	J445	IV	M	*0.4*	0.3	*0.2*	*1.6*	1.3	*1.1*	0.3	0.6

TABLE II—*Continued.*

Designation		Older Wood								First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells			Vessel segments	Other tracheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.	Mean	Mean
Illipe Betis Merrill.	571	IV	M	*1.0*	0.6	*0.4*	*1.5*	1.3	*1.1*		
Palaquium luzoniense Vidal.	577	III	M	*1.4*	1.2	*0.7*	*2.6*	1.9	*1.2*	0.7	0.9
philippense C. B. Robinson.	576	III	O	*1.1*	0.8	*0.6*	*1.8*	1.5	*1.1*		
Sideroxylon species.	924	III	O	*0.8*	0.7	*0.6*	*1.5*	1.3	*1.1*		
101. Ebenaceae.											
Diospyros philippinensis A. DC.	137	IV	O	*0.5*	0.4	*0.3*	*1.0*	0.9	*0.7*		
virginiana Linn.	J452	IV	O	*0.5*	0.4	*0.3*	*1.3*	1.0	*0.8*	0.4	0.6
Maba sandwicensis A. DC.	905	IV	M	*0.4*	0.3	*0.2*	*1.1*	1.0	*0.8*		
102. Symplocaceae.											
Symplocos tinctoria L'Hérit.	J97	I	O	*1.4*	1.1	*0.6*	*2.2*	1.6	*1.2*	0.5	0.8
103. Styracaceae.											
Halesia diptera Linn.	J454	I	M	*1.1*	0.9	*0.8*	*2.3*	1.6	*1.3*	0.7	0.9
XXVIII. Contortae.											
104. Oleaceae.											
Fraxinus americana Linn.	J456	IV	O	*0.4*	0.3	*0.2*	*1.2*	0.8	*0.7*	0.2	0.6
Olea lanceolata Hook. f.	492	III	Y	*0.6*	0.4	*0.3*	*1.4*	1.2	*0.9*		
Schrebera swietenioides Roxb.	493	III	O	*0.5*	0.4	*0.3*	*1.6*	1.4	*0.8*		
105. Loganiaceae.											
Fagraea fragrans Roxb.	362	IV	O	*0.6*	0.5	*0.4*	*1.6*	1.3	*1.0*		

Geniostoma ligustrifolium A. Cunn.	363	III	O	*0.7*	0.6	*0.4*	*1.0*	0.9	*0.6*	0.5	0.8
Strychnos species.	364	IV	O	*0.7*	0.5	*0.4*	*2.1*	1.7	*1.2*		
106. Apocynaceae.											
Alstonia macrophylla Wall.	100	IV	O	*1.1*	0.9	*0.6*	*2.0*	1.5	*1.0*		
Rauwolfia sandwicensis A. DC.	976	*III*	M	*1.2*	1.0	*0.8*	*1.9*	1.6	*1.1*	0.5	0.8
Wrightia tinctoria R. Br.	N1115	IV	M	*0.5*	0.3	*0.2*	*1.0*	0.8	*0.6*		
107. Asclepiadaceae.											
Asclepias species.	1094	IV	M	*0.2*	0.2	*0.1*	*0.8*	0.6	*0.4*		
XXIX. Tubiflorae.											
108. Hydrophyllaceae.											
Eriodictyon tomentosum Benth.	1004	III	Y	*0.6*	0.5	*0.3*	*1.0*	0.8	*0.7*		
109. Borraginaceae.											
Bourreria havanensis Miers.	J471	IV	M	*0.5*	0.3	*0.2*	*1.1*	0.9	*0.6*	0.3	0.6
Cordia Gerascanthus Linn.	1619	IV	M	*0.4*	0.3	*0.2*	*2.0*	1.7	*1.4*		
Ehretia Wallichiana Hook. f. & Thoms.	941	III	O	*0.6*	0.5	*0.4*	*2.4*	1.9	*1.0*		
110. Verbenaceae.											
Avicennia officinalis Linn.	632	IV	M	*0.3*	0.2	*0.2*	*1.4*	1.2	*1.0*	0.2	0.4
Premna longifolia Roxb.	1054	IV	O	*0.9*	0.5	*0.3*	*1.4*	1.2	*1.0*		
Vitex Aherniana Merrill.	624	IV	O	*0.6*	0.5	*0.4*	*1.7*	1.4	*1.1*		
111. Solanaceae.											
Nicotiana glauca R. Grah.	855	IV	M	*0.4*	0.3	*0.2*	*1.0*	0.9	*0.6*		
Solanum auriculatum Ait.	1462	IV	M	*0.5*	0.3	*0.2*	*0.8*	0.7	*0.5*		
sandwicense Hook. & Arn.	948	IV	M	*0.4*	0.3	*0.2*	*1.1*	0.8	*0.5*		
112. Scrophulariaceae.											
Paulownia imperialis Sieb. & Zucc.	579	IV	M	*0.4*	0.3	*0.2*	*1.2*	0.9	*0.6*		
113. Bignoniaceae.											
Catalpa speciosa Warder.	J476	IV	O	*0.4*	0.3	*0.2*	*1.0*	0.8	*0.5*	0.1	0.3
Tabebuia pentaphylla Hemsl.	1603	IV	M	*0.4*	0.3	*0.2*	*1.1*	0.9	*0.7*		
114. Gesneriaceae.											
Rhabdothamnus Solandri A. Cunn.	1172	III	Y	*0.6*	0.5	*0.2*	*0.8*	0.7	*0.4*		

TABLE II—*Concluded.*

Designation				Older Wood						First Annual Ring	
		Type	Age	Vessel Segments			Other tracheary cells			Vessel segments	Other tracheary cells
Plant	No.			Max.	Mean	Min.	Max.	Mean	Min.	Mean	Mean
115. Myoporaceae.											
Myoporum laetum Forst.	488	IV	M	*0.5*	0.4	*0.3*	*1.5*	1.3	*0.9*		
sandwicense A. Gray.	972	IV	M	*0.6*	0.4	*0.3*	*1.1*	0.9	*0.6*	0.3	0.5
XXX. Rubiales.											
116. Rubiaceae.											
Cephalanthus occidentalis Linn.	J482	IV	M	*0.6*	0.5	*0.4*	*1.1*	0.9	*0.6*		
Nauclea media Havil.	531	IV	M	*1.1*	0.8	*0.6*	*1.8*	1.6	*1.4*		
Straussia hawaiensis A. Gray.	988	III	M	*0.8*	0.5	*0.4*	*1.1*	0.9	*0.6*	0.4	0.5
117. Caprifoliaceae.											
Lonicera involucrata Banks.	J512	III	M	*0.6*	0.5	*0.4*	*1.1*	0.8	*0.7*	0.4	0.7
Sambucus nigra Linn.	J189	III	M	*0.4*	0.3	*0.2*	*1.3*	1.1	*0.9*	0.3	0.5
Viburnum Lentago Linn.	J491	I	O	*1.2*	1.0	*0.8*	*1.8*	1.5	*1.2*		
XXXI. Campanulatae.											
118. Compositae.											
Baccharis halimifolia Linn.	J501	IV	M	*0.2*	0.2	*0.1*	*0.7*	0.5	*0.3*	0.2	0.3
Dubautia plantaginea Gaudich.	946	IV	M	*0.4*	0.3	*0.2*	*0.9*	0.7	*0.6*		
Perymenium species.	1564	IV	M	*0.4*	0.3	*0.2*	*1.1*	0.9	*0.7*		
Vernonia species.	1046	IV	M	*0.3*	0.2	*0.1*	*0.4*	0.3	*0.2*		

The most salient features of these tables are the following: (1) There is a marked contrast in length between the innermost or first formed and subsequently formed tracheary elements of the secondary xylem. In Ginkgo and the Coniferae, the latter are from 200–600 percent longer than the former. There is a similar, though less pronounced, contrast in size between the innermost and outermost tracheids, fiber-tracheids and libriform fibers of the secondary xylem of dicotyledons. (2) The vessel-segments of the dicotyledons are invariably somewhat shorter than the surrounding tracheary elements of the secondary xylem; but in certain stems, the vessel-segments of the first formed growth layers are of the same length as those which occur in the later formed wood. (3) Although extremely variable in size, the tracheids of Gymnosperms are, on an average, noticeably longer than equivalent tracheary elements of dicotyledons, Table III. This contrast in size is somewhat less conspicuous in the case of the tracheary elements of the first formed secondary xylem. (4) In the dicotyledons, the fiber-like tracheary elements tend to become shorter as the vessel-segments decrease in length, Table III. (5) In the dicotyledons, there is no close correlation between the size of the tracheary elements and the various types of floral organization which form the basis of the Engler and Gilg (1912) system of classification. (6) In the Coniferae, the tracheary elements of the Taxaceae and Cupresseae average somewhat shorter, and those of the Taxodieae and Araucarieae somewhat longer, than the tracheids of the Abieteae, Table III.

Sanio (1872) came to the conclusion that in the stems and branches of *Pinus sylvestris* Linn. the tracheids everywhere increase from within outwards, throughout a number of annual rings, until they have attained a definite size, which then remains constant for the following annual rings. Shepard and Bailey (1914) and subsequently Miss Gerry (1915) and Lee and Smith (1916) have shown that Sanio's law is not applicable to conifers in general. In *Pinus Strobus* Linn., *P. palustris* Mill., *Picea rubens* Sarg., *Pseudotsuga taxifolia* Britton, *Tsuga canadensis* Carr., and *Abies concolor* Lindl. and Gord., the tracheids were found to increase rapidly in length for a period of years, varying from 20–60; but no constant length was attained even in trees several hundred years old. Following the first period of rapid increase in length the size of the tracheids fluctuated more or less during the subsequent growth of the plant. Similar results have been

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[5] Sanio's constants occurred after 18–40 years.

TABLE III.

GYMNOSPERMAE — DICOTYLEDONEAE.

SECONDARY XYLEM OF STEM.

Frequency distribution of average lengths of tracheary elements.

Designation	No. Ind.	Class Centers									
		.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	2.9
Gymnosperms: Outer Tracheids	152	....	....	....	...	1	4	12	10	19	13
" Inner "	48	....	5	27	13	3	....	....	....	....	....
Dicotyls: Outer "Fibers"	275	4	26	66	66	53	35	13	3	4	4
" Inner "	81	5	37	26	10	2	1	....	....	....	....
" Outer Vessel-segments	275	76	104	49	29	7	7	3	....	....	....
" Inner "	81	35	26	19	...	1	....	....	....	....	....
Araucarieae: Outer Tracheids.	6	....	....	....	....	....	....	....	....	....	....
Taxodieae: " "	10	....	....	....	....	....	....	....	....	1	1
Abieteae: " "	88	....	....	....	....	....	1	5	4	10	11
Taxaceae: " "	15	....	....	....	....	....	1	3	2	3	....
Cupresseae: " "	27	....	....	....	....	1	2	4	4	5	1
Dicotyls I: Outer "Fibers"	53	....	3	4	9	9	12	6	2	3	4
" I: Inner "	28	....	4	13	8	2	1	....	....	....	....
" IV: Outer "	169	4	21	50	48	29	13	4	....	....	....
" IV: Inner "	36	5	27	4	....	....	....	....	....	....	....
" I: Outer Vessel-segments	53	1	3	17	15	7	7	3	....	....	....
" I: Inner "	28	....	11	16	....	1	....	....	....	....	....
" IV: Outer "	169	74	79	16	....	....	....	....	....	....	....
" IV: Inner "	36	32	4	..1.	....	....	....	....	....	....	....

TABLE III (*Continued*).

in Millimeters.														Statistical Constants	
3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5	6.8	7.1	Mean in. mm.	S D in mm.
23	12	11	5	12	6	7	7	2	0	1	5	1	1	3.53± .07	1.25± .05
....	....	....	....	(C)	....	....	....	(C)	....	....	....	....	....	.90± .02	.25± .02
1	....	....	....	(V)	....	....	....	....	....	....	....	....	....	1.20± .02	50± .01
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.69± .02	.28± 01
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.61± .02	.41± .01
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.45± .02	.26± .01
....	1	....	....	....	....	....	1	....	....	1	2	....	1	5.85± .32	1.18± .23
1	....	....	1	....	1	1	....	1	....	....	3	....	....	4.76± .31	1.44± .22
16	7	6	4	12	4	3	4	1	....	....	....	....	....	3.49± .07	.92± .05
3	....	2	....	....	....	1	....	....	....	....	....	....	....	2.82± .15	.86± .11
3	3	3	....	....	1	....	....	....	....	....	....	....	....	2.74± .10	.77± .07
1	....	....	....	....	....	....	....	....	....	....	....	....	....	1.64± .06	.67± .04
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.92± .04	.28± .03
....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.04± .02	.37± .01
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.49± .02	.14± .01
....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.12± .04	.41± .03
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.70± .02	.17± .02
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.40± .01	.20± .01
....	....	....	....	....	....	....	....	....	....	....	....	....	....	.24± .01	.10± .01

C — Cycads. V — Vesselless Dicotyls.

secured by the writers, *Figs. 1, 3,* and *4.* It seems probable, however, from the study of available data, that, although in most cases the length of the tracheids does not become constant in the older wood of individual stems of coniferous plants, the normal length-on-age curve for any particular species is of the general form illustrated in *Graph 16, Fig. 5.*

In any given plant, the length-on-age curve, or one or more portions of it, may deviate from the norm of the species, owing, in all probability, to the effects of various environmental factors. Thus, stunted or depauperate plants appear to have depressed curves, *Graphs 12, 12a, 5a, 5b, 14, 14a,* and *8.* Furthermore, the distorted tracheary tissue, formed subsequent to injury or in response to abnormal growth conditions, frequently possesses shorter tracheids than normal tissue, *A, Graphs 13* and *5a.* Similarly, tissue formed in regions of the plant where there are considerable mechanical stresses, e. g. at the junction of stems and roots or stems and branches or in bent or twisted stems, tends to have shorter tracheids than normal straight grained tissue. This is shown very clearly in the following table:

TABLE IV.

Pinus Strobus.

Stems one year old.

	Length tracheids mm.
Specimen No. 1.	
Wood from vicinity of branch whorl	0.43
Wood from stem between branch whorls	0.82
Specimen No. 2.	
Wood from vicinity of branch whorl	0.62
Wood from stem between branch whorls	0.96
Specimen No. 3.	
Wood from vicinity of branch whorl	0.65
Wood from stem between branch whorls	0.84
Specimen No. 4.	
Wood from vicinity of branch whorl	0.65
Wood from stem between branch whorls	0.99
Specimen No. 5.	
Wood from vicinity of branch whorl	0.71
Wood from stem between branch whorls	1.16

	Length tracheids mm.
Stems 25 years old	
Wood from vicinity of branch whorl	
First annual ring	0.6
10th " "	1.9
25th " "	2.2
Wood 6 inches from whorl	
First annual ring	0.9
10th " "	2.3
25th " "	3.6
Wood 12 inches from whorl	
First annual ring	1.0
10th " "	2.4
25th " "	3.8

Furthermore, Hartig (1901) and Shepard and Bailey (1914) have shown that the peculiar compression wood (*Rothholz*) which occurs on the under sides of branches and on the concave sides of bent stems is composed of shorter tracheids than the tension wood (*Zugholz*) which occurs on the opposite sides of the same branches or stems.

In view of these facts, the longest tracheids might be expected to occur in the old, straight grained wood of the "clear length" of the stem, or that portion between the swollen base and crown which is devoid of large branches. That longer tracheids do actually occur in this portion of the stem, is indicated by the measurements of Sanio (1872), Shepard and Bailey (1914) and Lee and Smith (1916), and is graphically shown in *Figs. 4* and *5*. *Graphs 17* and *17a* are of considerable interest in this connection. The secondary tracheids near the pith are of similar lengths at distances of from 2–154 feet above the level of the ground. On the other hand, the average length of the tracheids in the older wood — last 60–100 annual rings — is considerably less in the 2–26 and 138–154 foot sections of the stem. In other words, it seems probable that as a plant becomes older, the depressing effect of the conditions at the base of the plant extends further and further up the stem, and persistent branches have a progressively greater influence upon the surrounding tissue of the main axis of the plants. Therefore, in certain sections removed from the bases and tops of large trees, it is not uncommon to find that the tracheary elements — after increasing in length for a period of years — tend to become shorter in the outermost rings of the stem; a phenomenon which might easily be mistaken for senility, *Graph 5b, Fig. 3.*

It is evident, accordingly, that the means in Table I cannot be considered *a priori*, as the tracheary size norms of the species listed. However, in view of the varied character of the material studied, the table as a whole may be considered to give a fairly reliable indication of the general size (length) variations that occur in the tracheary elements of the stems of Coniferae. Long tracheids tend to occur in the "clear lengths" of the stems of tall, rapidly growing forest trees; short tracheids in xerophytes, small, slowly growing or depauperate individuals, and plants whose stems are clothed nearly to the level of the ground, with large persistent branches. In Table III, the proportion of the former types of growth forms is higher in the Taxodieae and Abieteae than in the Taxaceae and Cupresseae.

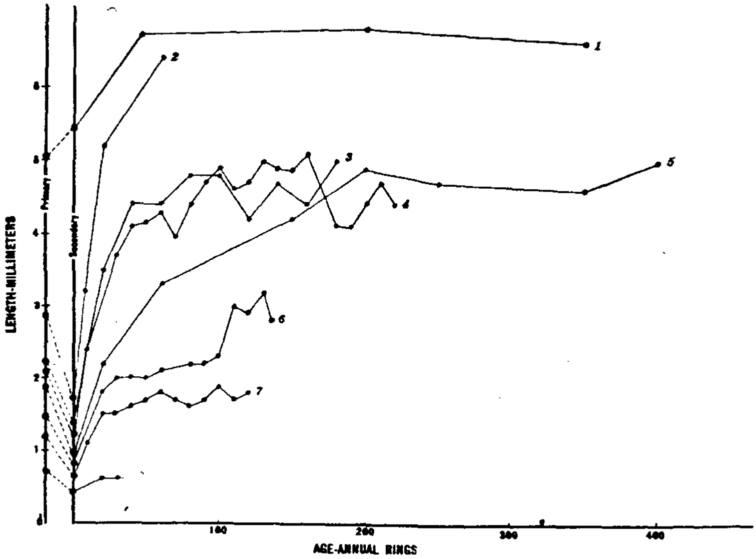

FIGURE 1. Graphs illustrating variation in length of tracheids in passing from the innermost to the outermost secondary xylem. Lengths of primary tracheids shown for comparison. 1. *Dioon spinulosum;* 2. *Araucaria Bidwillii;* 3. *Pseudotsuga taxifolia*, after Lee and Smith; 4. *Pinus palustris;* after Shepard and Bailey; 5. *Pinus ponderosa*, 6. *Cedrus Libani;* 7. *Taxus brevi folia;* 8. *Pinus albicaulis.*

It has been shown in Table II that, in the stems of dicotyledons, the first formed tracheids, fiber-tracheids and libriform fibers tend to be considerably shorter than the later formed elements of the secondary xylem. The segments of vessels are usually somewhat shorter in the first formed than the older secondary xylem, although this is not invariably the case, particularly in plants listed as of Group IV. In this group, relatively short vessel-segments may be of the same length in the innermost and outermost parts of the secondary xylem, a phenomenon noted by Sanio (1873–74) in certain Leguminosae.

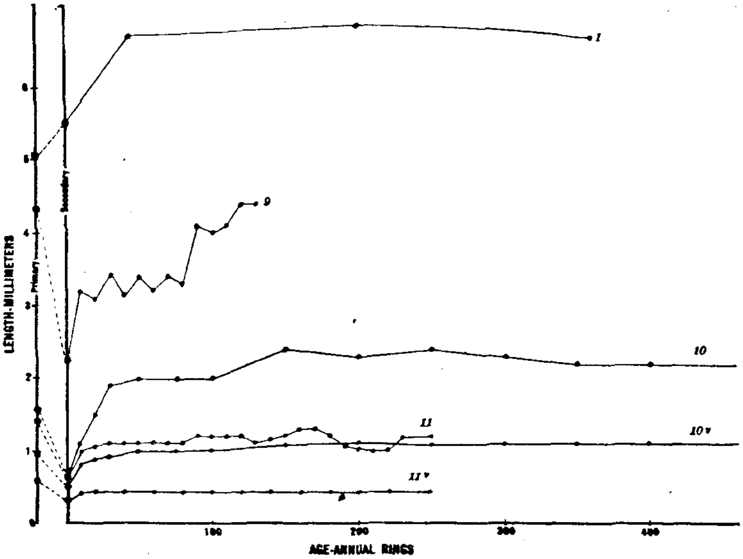

FIGURE 2. Graphs illustrating variation in length of tracheary elements in passing from innermost to outermost secondary xylem. Lengths of primary elements shown for comparison. 1. *Dioon spinulosum;* 9. *Trochodendron aralioides*, vesselless arborescent dicotyledon, stunted specimen; 10. *Liriodendron tulipifera*, fiber-tracheids; 10v. *Same*, vessel-segments; 11. *Carya ovata*, fiber-tracheids after Pritchard and Bailey; 11v. *Same*, vessel-segments after Pritchard and Bailey.

As is indicated in *Figs. 2* and *4*, *Graphs 10, 10v, 11, 11v, 15* and *15v*, the tracheary elements in the first formed growth layers of most arborescent and fruticose dicotyledons become progressively longer for a period of from 5–20 years. During succeeding growth in diameter of the stem, the length of the elements remain nearly constant or fluctuate more or less, apparently in response to environmental influences. Injuries or other abnormal growth conditions tend to cause the formation of shorter tracheary elements, *A Fig. 4, Graphs 15* and *15v.* Similarly, the size of the tracheary cells tends to be less in nodes, junctions of stems and roots or branches and other regions where growth adjustments are taking place, Table V.

TABLE V.

	Node	*Internode*
Trochodendron aralioides		
Tracheids of first two rings	1.4 mm.	1.9 mm.
Carya ovata		
Fiber-tracheids of first two rings	0.5 mm.	0.6 mm.
Vessel-segments " " " "	0.2 mm.	0.3 mm.
	Stump	*"clear length"*
Betula lutea		
Fiber-tracheids of mature wood	1.2 mm.	1.7 mm.
Vessel-segments " " "	0.7 mm.	1.2 mm.

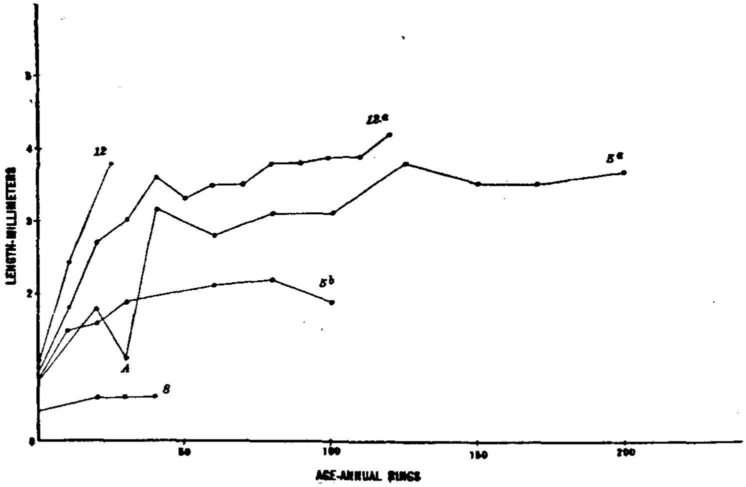

FIGURE 3. Graphs illustrating effects of environmental factors on lengths of tracheids. 12. *Pinus Strobus*, vigorous, rapidly grown specimen; 12a. *Same*, plant suppressed during first 60 years; 5a. *Pinus ponderosa*, effects of injury at *A*; 5b. *Same*, stunted specimen, 12 feet high at 100 years; 8. *Pinus albicaulis*, alpine plant, one foot high at 45 years.

Therefore, longer tracheary elements tend to occur in the "clear lengths" of the stems of tall, vigorous, rapidly growing forest trees, and shorter cells in small or depauperate plants, and stems which are covered with large persistent branches. However, the size of the tracheary elements varies considerably even in dicotyledons of similar growth forms. These fluctuations appear to be concomitants of certain structural changes in the xylem.

It was shown by von Mohl (1851) in the middle of the last century that vessels are compound structures which arise from series of cells by the loss of the pit membranes in the division walls between the members of the series. In certain types of secondary xylems, the vessel-segments closely resemble scalariform tracheids in general form and structure, *Fig. 6*. In these presumably more primitive types of vessels certain of the pits in the end walls of the individual tracheary cells have no pit membranes and are without well marked bordering areas of the secondary walls. These types of vessels grade into others in which the scalariform openings become larger and reduced in number and coalesce to form single large openings or pores. At the same

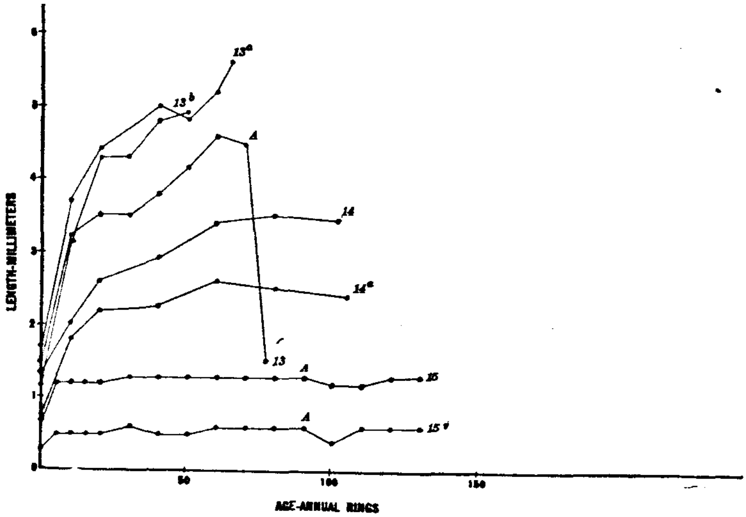

FIGURE 4. Graphs illustrating the effects of environmental factors on the length of tracheary elements. 13. *Pinus Taeda*, section 1½ feet from ground, effects of injury at A; 13a. *Same*, section 32 feet from ground; 13b. *Same*, section 62 feet from ground; 14. *Pinus contorta* var. *Murrayana*, vigorous specimen; 14a. *Same*, stunted specimen; 15. *Swietenia Mahogoni*, libriform fibers, effects of injury at A; 15v. *Same*, vessel-segments, effects of injury at A.

time the constituent cells of the vessels become wider and their ends tend to become less tapering. The most specialized condition results in the formation of tubes of relatively large bore which are composed of wide segments with nearly horizontal end walls.

In Table II, four categories of vessels have been recognized. In group I, the perforations are prevailing scalariform; in group II, intermediate between scalariform and porous; and in groups III and IV, prevailing porous *Fig. 6*. The vessel-segments in group III differ from those in group IV in having well marked tapering ends, thus resembling tracheids in general outline.

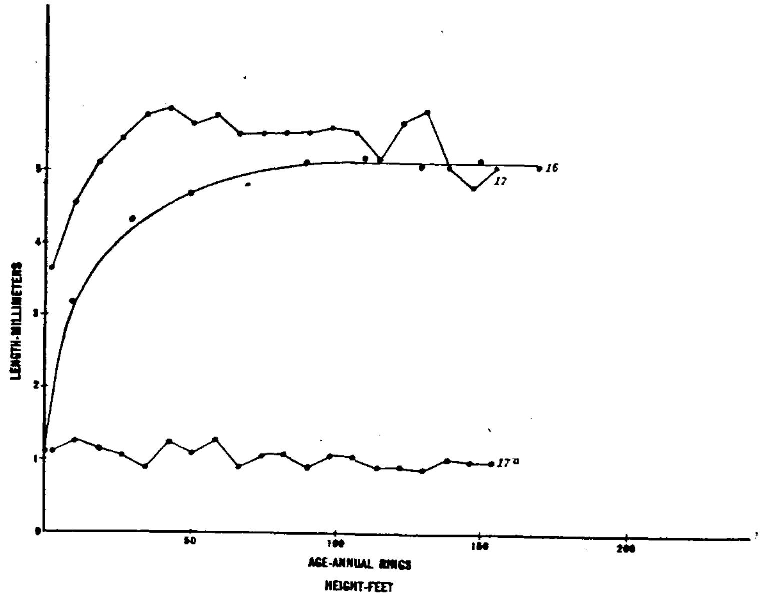

FIGURE 5. Graph 16. *Pseudotsuga taxifolia*, average length-on-age curve, for eight sections removed from different trees and at different heights; 17. *Same*, average lengths of tracheids in outer rings of a large stem, at heights of from 2–154 feet above the level of the ground; 17a. *Same*, Length of tracheids in first annual ring, at heights of from 2–154 feet above the level of the ground.

That tracheary elements tend to shorten as vessels become more highly differentiated is indicated by the data in Tables II and III. If the material in the various groups were made strictly comparable, it would tend to accentuate the differences between the lengths of the

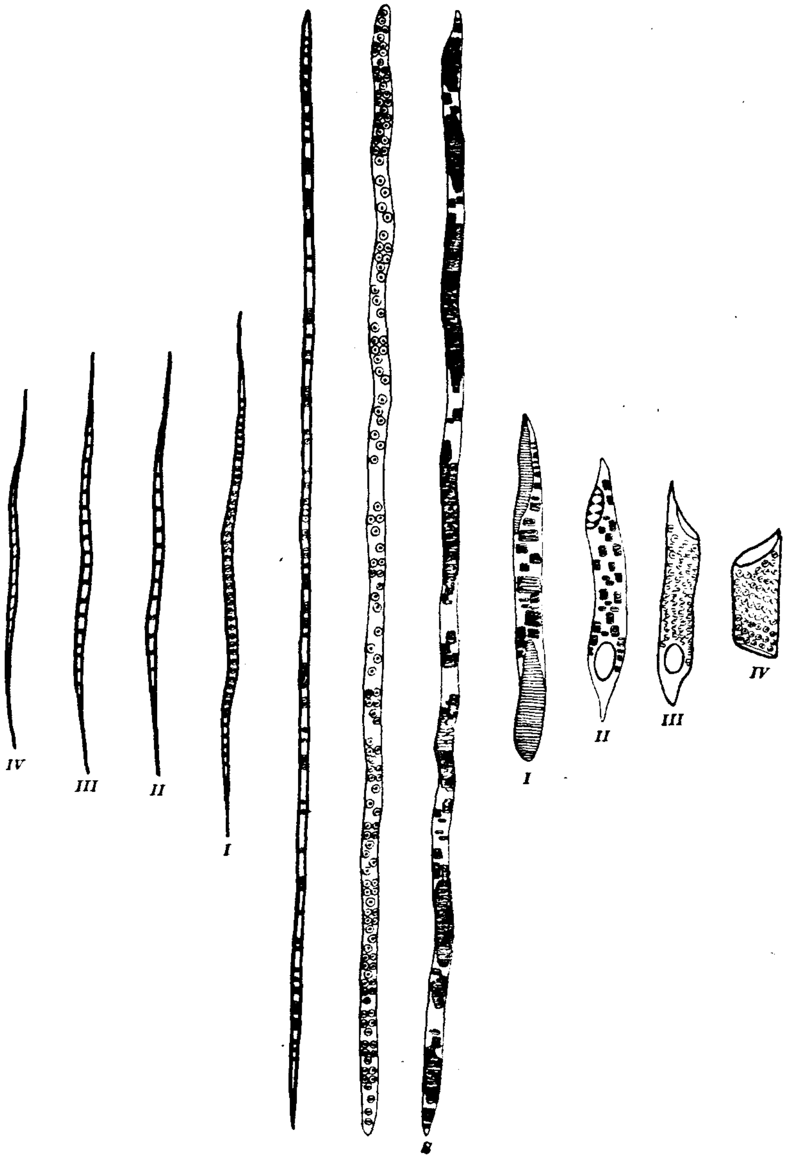

Figure 6. Diagrammatic illustration of average size and structure of tracheary elements in the mature wood of Coniferae and various groups of Dicotyledoneae, based upon measurements in Tables I and II. S. Scalariform tracheid of Trochodendron or Dioon, not drawn to scale.

elements in groups I and IV. For example, in groups I and II, 12 percent of the specimens are less than 15 years old, whereas in groups III and IV 5 percent are less than 15 years old.

It is evident, accordingly, that there is an important correlation between the size of tracheary elements in arborescent and fruticose Dicotyledons and certain types of differentiation of the secondary xylem. As the vessels become wider and more highly specialized structurally, the tracheary elements tend to become shorter. Not only do the elements tend to become shorter, but the bordered pits in their lateral walls become correspondingly modified, Table VI.

TABLE VI.

Angiospermae — Dicotyledoneae.

Types of lateral pitting.

Group I	Vessel-segments:	Scalariform and opposite	86%
“	“ “ :	Opposite and alternate or alternate	14%
“	Other tracheary cells:	Medium or large borders	63%
“	“ “ “ :	Small borders	20%
“	“ “ “ :	Borders vestigial or absent	17%
Group II	Vessel-segments:	Scalariform and opposite	80%
“	“ “ :	Opposite and alternate or alternate	20%
“	Other tracheary cells:	Medium or large borders	35%
“	“ “ “ :	Small borders	30%
“	“ “ “ :	Borders vestigial or absent	35%
Group III	Vessel-segments:	Scalariform and opposite	11%
“	“ “ :	Opposite and alternate or alternate	89%
“	Other tracheary cells:	Medium or large borders	07%
“	“ “ “ :	Small borders	33%
“	“ “ “ :	Borders vestigial or absent	60%
Group IV	Vessel-segments:	Scalariform and opposite	06%
“	“ “ :	Opposite and alternate or alternate	94%
“	Other tracheary cells:	Medium or large borders	05%
“	“ “ “ :	Small borders	12%
“	“ “ “ :	Borders vestigial or absent	83%

In groups III and IV, alternate-multiseriate pitting predominates in the lateral walls of the vessels, whereas, in groups I and II, scalariform and opposite-multiseriate pitting are much in evidence. The tracheary elements which surround the vessels in groups I and II usually have conspicuous bordering areas about the pit orifaces in their lateral secondary walls, but this is not the case in groups III and IV. In other words, with increasing specialization certain tracheary cells become highly modified and serve principally as conductors of liquids, whereas others gradually cease to serve in that capacity, and become modified as mechanical or skeletal elements, *Fig. 6*. Each line of specialization appears to involve a general tendency towards reduction in the length of the tracheary elements and concomitant changes in the structure and arrangement of the pits.

Furthermore, as the secondary xylem becomes more and more highly differentiated, the contrast in length — in the later formed growth layers — between vessel-segments and surrounding tracheary elements usually becomes correspondingly accentuated.

The fact that vessel-segments are shorter than the tracheids, fiber-tracheids or libriform fibers which surround them, and that, in the dicotyledons, the tracheary elements become shorter as the vessels become more highly differentiated, suggests that the striking general contrast in cell length between the secondary tracheary elements of the gymnosperms and dicotyledons may be closely correlated with the evolution of vessels in the later group of plants. That the reduced size (length) of the tracheary elements in the dicotyledons is associated in some way with the development of vessels is emphasized, furthermore, by the fact that such vesselless arborescent plants as Trochodendron and Drimys have the longest tracheary elements of any of the dicotyledons investigated, *Table VII*. In addition it is significant that the tracheary elements of the secondary xylem of the Gnetales, supposed gymnosperms with vessels, resemble in length those that occur in many dicotyledons, *Table VII*.

TABLE VII.

	Vesselless Angiosperms.	
Trochodendron aralioides Sieb. & Zucc.	Tracheids	4.5 mm.
Drimys Winteri Forst.	"	4.3 mm.
	Gnetales.	
Ephedra californica S. Wats.	Vessel-segments	0.7 mm.
	Tracheids	0.8 mm.
Gnetum Gnemon Linn.	Vessel-segments	1.5 mm.
	Tracheids	1.9 mm.
Welwitschia mirabilis Hook. f.	Vessel-segments	0.7 mm.

SIZE OF TRACHEARY ELEMENTS IN VASCULAR CRYPTOGAMS AND OLDER GYMNOSPERMS.

The tracheids in the vascular cryptogams appear to have been of such unusual length as to attract the attention of many paleontologists. The great length of the secondary tracheids in Calamites led Williamson (1871) to describe them as vessels — compound structures — in one of his earlier papers. Williamson and Scott (1894) described the tracheary elements of Sphenophyllum as follows: "If they were tracheids they must have been of great length, for they can often be traced all through a section without finding any terminal wall." In another paper, these writers (1895) stated that in Lyginodendron the secondary "tracheids are of great length" and that in Heterangium "their length must have been great as terminations are by no means frequently seen." Williamson (1873) had previously stated in regard to the tracheary elements of *Dictyoxylon Oldhamium:* "It is very difficult to measure their length, because, owing to its amount which is considerable, and to their interlacing freely within their respective bundles, it is almost impossible to see the extremities of each fiber; it is, however, sufficiently great to give them an almost vascular character." Similar descriptions have been recorded by other paleontologists.

Through the courtesy of Drs. G. R. Wieland and E. W. Berry, the writers secured the opportunity of examining sections of well preserved fossil stems of various representatives of the Calamariales, Sphenophyllales, Lepidophytineae and Cycadofilices, and of verifying the statements of previous investigators. The tracheary elements of the secondary xylem in such forms as Calamites, Sphenophyllum, Lepidodendron, Sigillaria, Lyginodendron, Heterangium and other Cycadofilices were undoubtedly very long, averaging usually several millimeters. The first formed secondary tracheids appear to have been as long if not longer than the primary tracheids, but the tracheids of nodal wood — at least in the Calamariales — were apparently somewhat shorter than those of the internodal wood.

The secondary tracheary elements in living representatives of the Cycadales, and in fossil stems of Bennettitales and Cordaitales, resemble in length the tracheids of the vascular cryptogams mentioned above. Although the later formed secondary tracheids may be somewhat longer than those formed by the first activity of the cambium, the latter — in contrast to similar elements of Ginkgo, the Coniferae and Dicotyledoneae — frequently appear to be relatively long and of nearly the same length, if not actually longer, than the outermost elements of the primary wood, *Graph 1, Fig. 1*. This is in marked contrast to the conditions which occur in the rest of the gymnosperms and woody dicotyledons, in which the primary tracheary elements average as a rule considerably longer than the innermost elements of the secondary xylem, *Figs. 1* and *2*. In other words, the most striking differences in length between the tracheary elements of the higher and lower gymnosperms occur commonly in the innermost cells of the secondary xylem, *Figs. 1* and *2*. Furthermore, whereas, in the older gymnosperms and vascular cryptogams, the secondary xylem of small plants may be composed of relatively long tracheids, the smaller growth forms of the Coniferae tend to have comparatively short tracheids even in the outermost portions of the secondary wood.

SUMMARY.

A comparative study of the secondary xylem of vascular plants reveals a number of interesting facts in regard to the length of the secondary tracheary elements in vascular cryptogams, gymnosperms and angiosperms. The tracheary elements of the secondary xylem in the vascular cryptogams tended to be very long, whereas those which occur in the dicotyledons — with the notable exception of the vesselless Trochodendroceae and Magnoliaceae — are comparatively short. The gymnosperms appear to occupy an intermediate position between these extremes; the Cordaitales, Bennettitales and Cycadales resembling the vascular cryptogams, and the Gnetales — supposed gymnosperms with vessels simulating the angiosperms.

The reduction in the size (length) of the tracheary elements of the higher plants appears to have proceeded along certain general and more or less distinct lines.

(1) In all the dicotyledons and gymnosperms with the exception of the Cordaitales, Bennettitales and Cycadales, the first formed tracheary cells of the secondary xylem are relatively small, and in all of the material examined by the writers are considerably shorter than the adjoining elements of the primary xylem and subsequently formed tracheary cells of the secondary xylem, *Figs. 1* and *2*.[6]

---

[6] In dicotyledons having very highly differentiated types of vessels, the short vessel-segments may be of nearly uniform size in succeeding growth layers of the secondary xylem.

This is in marked contrast to the conditions which prevailed in the stems of many of the lower vascular plants. In those forms — which possessed relatively wide zones of primary wood — the innermost tracheids of the secondary xylem appear to have resembled in size the elements of the primary xylem. It seems probable, therefore, that in the evolution of the higher gymnosperms and dicotyledons, with reduction in the amount of primary xylem and other changes in the innermost portion of the stele, there has been a concomitant shortening of the first formed tracheary elements of the secondary xylem.

(2) Another tendency towards reduction in the length of the tracheary elements of the secondary xylem appears to be associated with the evolution and differentiation of vessels. The secondary tracheary tissue of the vascular cryptogams and gymnosperms is comparatively simple and composed of cells of a single generalized type, the so-called tracheids. In the evolution of the Gnetales and Dicotyledoneae, specialization or division of labor appears to occur among these cells. Certain vertical series of tracheids become modified and function principally in conducting liquids whereas others become highly modified as mechanical or skeletal elements, *Fig. 6*. That this process of specialization involves a reduction in the length of the tracheary elements, is indicated, not only by the striking general contrasts between the cells of the xylem in the dicotyledons and gymnosperms or vascular cryptogams, but also by the interesting fact that the vesselless Trochodendraceae and Magnoliaceae have very long tracheary elements, and the Gnetales comparatively short ones, such as occur in many dicotyledons. As the vessels of the secondary xylem become more and more highly differentiated their segments gradually lose their resemblance to tracheids, *Fig. 6*, and tend to become progressively wider and shorter. At the same time, the structure and arrangement of the bordered pits in their lateral walls tends to be considerably modified, *Table VI*. Furthermore, the surrounding tracheary elements tend to shorten and to take on a more fiber-like structure, their pits becoming vestigial by the gradual disappearance of the bordering areas of the secondary walls. During these processes of specialization, the reduction in length of the vessel-segments usually exceeds that which occurs in the remaining tracheary elements. That is to say, there is less contrast in length between vessel-segments and surrounding tracheary elements in Group I than in Group II of the dicotyledons.

In addition to these striking tendencies toward reduction in the length of tracheary elements, there are indications of other variations in cell length which seem to be induced by different factors.

In the Coniferae — among plants of comparable ages — the smaller, slower growing forms, e. g. certain Taxoceae and Cupresseae, tend to have shorter elements than larger, more rapidly growing forms. Furthermore, within the same species, dwarfed or depauperate plants tend to be composed of shorter tracheary elements than normal individuals. Similar tendencies occur among the dicotyledons. It is important to note in this connection, that the tracheary elements formed about the junctions of stems and roots, branches, or leaf traces, wound tissue, compression wood, and similar tissue in which growth adjustments are taking place, tend to be considerably shorter than those which occur in normal internodal or straight grained wood, *Figs. 3, 4,* and *5, Tables IV* and *V.* Of course, the abundance and distribution of this short celled tracheary tissue varies considerably in plants grown in different environments and in plants of different growth habits. Thus, tall forest trees whose stems are devoid of branches over a considerable length of their stem, appear to have longer tracheary cells than non-gregarious trees whose stems are clothed nearly to the level of the ground with large branches. Similarly, gnarled or twisted trees, such as occur commonly in alpine regions and other windswept or exposed situations, have shorter tracheids than erect plants of more sheltered habitats.

In so far as the length of the tracheary elements of the secondary xylem of vascular plants in general is concerned, there is no absolute correlation between body size and cell size. The tracheary elements in large dicotyledons may be considerably smaller than those that occur in comparatively small gymnosperms or vascular cryptogams. Similarly a gigantic sequoia may have shorter cells than a small cycad. Although the secondary tracheary elements in the Coniferae and Dicotyledoneae increase in size as the plants become larger, this phenomenon lasts for only a comparatively limited number of years, after which the size is subject to comparatively slight fluctuations.

It is to be emphasized in conclusion that the primary object of an extensive reconnaissance survey of this character should be to blaze the way for subsequent and more intensive investigations. Having blocked out certain of the more important size variations that occur in the tracheary cells of the secondary xylem of vascular plants, it is essential to isolate and study the factors which regulate or control these phenomena. Of course, the length of the tracheary elements of the secondary xylem is dependent upon (1) the length of the cambial mother cells which form them and (2) the amount of elongation which they undergo during differentiation. A detailed discussion of the size variations of cambial cells, and the elongation of their daughter cells during differentiation, will be undertaken in the second paper of this series.

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CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. NO. LXXXII.

NEW LABOULBENIALES FROM CHILE AND NEW ZEALAND.

BY ROLAND THAXTER.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORIES OF HARVARD UNIVERSITY. No. LXXXII.

NEW LABOULBENIALES FROM CHILE AND NEW ZEALAND.

By Roland Thaxter.

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During a stay of several months in Chile, which extended from November, 1905 to March, 1906, the writer paid but scant attention to the collection of Laboulbeniales; since, in the absence of any very considerable number of insect hosts, his time and attention was largely occupied with the very rich cryptogamic flora of this region, large collections of which were made. The comparative rarity of hosts, especially in the heavily forested area about Corral, was surprising; and, with few exceptions, the parasites which occurred on them were not characterized by any unusual peculiarities. Less than fifty species were obtained, many of which were familiar. Among the latter may be mentioned *Herpomyces Ectobiae*, *Laboulbenia diversipes*, *L. granulosa*, *L. sigmoidea*, *L. pedicillata*, *L. polyphaga*, *L. Pterostichi*, *L. Tachyis*, *L. variabilis*, *L. vulgaris*, *Corethromyces Stilici*, *Acompsomyces brunneolus*, *Ecteinomyces Trichopterophilus*, *Ceratomyces mirabilis*, *C. filiformis*, and *Coreomyces Corisae*. A small number of forms were also found which, although new, were not in sufficiently good condition for description. These include two species each of *Rhachomyces*, *Mimeomyces* and *Corethromyces*, as well as several species of *Laboulbenia*, a genus now in some confusion. *Stigmatomyces Chilensis*, described in These Proceedings, **52**, p. 685, should also be added to the list of forms obtained.

The flora of southern Chile and New Zealand being similar in many respects, I have ventured to include in the present enumeration five species which were found in a small lot of beetles very kindly collected for me by Messrs. Eames and Sinnott at Aukland, in 1910. I am further indebted to Mr. Gilbert J. Arrow of the British Museum for several determinations.

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DIANDROMYCES nov. gen.

Axis of the receptacle coincident with that of the appendage and consisting of a series of superposed cells, the three lower constituting the receptacle proper, the subbasal cell of which produces two compound antheridia which are placed symmetrically on either side, and subtend two perithecia similarly developed from the third cell. Appendage multicellular, its lower cells developing branches right and left. Perithecia normal. Antheridia consisting of a stalk-cell, and a small basal cell which subtends four or five antheridial cells discharging into a well developed neck.

This type is not nearly related to that of any described genus unless it be *Dichomyces*. The continuity of the axes of its receptacle and appendage is similar to the condition found in *Monoicomyces*, and its general appearance is not unlike that of simpler species of this genus. The relations of the antheridia are, however, wholly different, and their structure is more like that of some of the better developed species of the unisexual *Dimeromyces*.

Diandromyces Chilenus nov. sp.

Brownish yellow. Basal and subbasal cells of nearly equal length or the latter somewhat longer; the basal cell abruptly narrower, or tapering continuously from base to apex; the subbasal somewhat longer than broad, and slightly narrower above; the third cell shorter, flattened, rounded: the basal cell of the appendage, (fourth cell), larger, separating a subtriangular cell from its distal half on either side which forms the base of a simple branch; the fifth and sometimes the sixth cells producing one, or often two, branches in a similar fashion, or more often without the small basal cell; the rest of the appendage running into an elongate, rather stout, simple, slightly tapering terminal portion. Stalk-cells of the antheridia subtriangular, occupying two thirds or more of the outer margin of the subbasal cell, their outer wall very thick and browner; the antheridium divergent at an angle of about 45°, the four or five antheridial cells subtended by a flattened basal cell: the venter tapering, but rather clearly distinguished from the straight rigid neck; which is slightly longer and nearly uniform. Stalk-cells of the perithecia short, abruptly broader above their narrow origins from cell three, which are slightly anterior; the secondary stalk-cell somewhat rounded, much broader than long, occupying the whole width of the region on the anterior side; the basal cell region broad and not clearly distinguished from the ascigerous region, which it slightly overlaps; the body of the perithecium slightly inflated below, subconical, stout, subsymmetrical; the tip short, distinguished by a slight indentation of the outline; the apex slightly longer, its extremity flat-conical. Spores about $35 \times 3\,\mu$. Perithecium above stalk-cell $90–105 \times 30–40\,\mu$. Antheridia above stalk-cell $35\,\mu$. Receptacle average $70\,\mu$. Appendage, longer $225\,\mu$. Total length to tips of perithecia $150–190\,\mu$.

On the elytra, abdomen, etc. of *Leptoglossa sculpticollis* Fvl., Corral, Chile, No. 1899.

Well developed specimens of this species are almost perfectly bilaterally symmetrical, the divergence of the paired antheridia and perithecia increasing with age. The elongate distal portion of the appendage is soon broken off, and persists in few even of the younger specimens. The host has been kindly determined by Dr. Fenyes.

Dichomyces Chilensis nov. sp.

Pale yellow tinged with brown, more deeply on the right side; asymmetrical through the somewhat greater development of the tiers at the right, and the greater length of the left perithecium; form rather stout, with a slight curvature to the right from base to apex. Basal cell large and broader than long, stained with blackish brown just above the foot. Second tier consisting of four cells, including a small cell separated at the right. Second tier consisting of usually twelve cells, five at the left and six at the right of the median cell, the paired antheridia large, conical, erect, pale brown. Third tier of usually about fourteen cells, one or two more at the right than at the left. Appendages rather short and unequal. Perithecia two, paired, arising on either side of the median cell, tilted slightly to the right, somewhat asymmetrical, uniformly pale brownish yellow, the apex subhyaline, the tip darker brownish; rather long, of nearly uniform diameter, slightly inflated, the tip rather clearly distinguished by its color and decreasing diameter; the apex as long, broad, distally flat conical, not quite symmetrical. Spores about 35 × 3.4 μ. Perithecium 75–100 × 22–25 μ. Total length to tip of perithecia 175–220 μ, greatest width 50–80 μ.

On *Quedius* sp., more often at the tip of the abdomen, No. 1522, Corral, Chile.

This species is well distinguished by its asymmetry of form and coloration, and the flat conical termination of its perithecia. Like other species of the genus it varies greatly in size and the number of cells in the tiers above the first is somewhat inconstant. As usual individuals with single antheridia and of somewhat stouter habit may occur on the legs.

Cantharomyces Andinus nov. sp.

General color brownish yellow, the basal cell and the stalk-cell nearly hyaline. Receptacle strongly geniculate, the basal cell somewhat longer than broad, of nearly uniform width, the lower half, or less, of its posterior wall involved in the blackening of the foot; subbasal cell short, broad, its anterior margin rather strongly convex, especially below; the posterior straight or slightly concave below; its posterior half or more suffused with brownish black, its upper margin horizontal. Appendage erect, or slightly bent outward; its stalk-cell hardly longer than broad, the upper third of the wall involved by a blackish brown shade especially conspicuous on the inner side; the antheridial segment about as large, or somewhat larger, squarish, or slightly broader than long, the antheridial area lateral and external, or somewhat irregular; the appendage above it consisting of from three to five cells, flattened, the two lower more so, their margins strongly convex, separated by constrictions at the thin dark brownish septa; the terminal cell producing distally, and one or two of those below it laterally, stout simple more or less erect branches, of which there may be four or five, usually coherent. Stalk of the perithecium rather short and stout, its base narrow, more than twice as broad distally, a more or less well defined somewhat irregular constriction just below the middle: basal cells clearly defined, subequal, irregularly rounded below, slightly concave above, the region somewhat prominent on either side below the venter; the venter, neck, tip and very short apex regions rather clearly indicated by corresponding depressions of the outline, which is straighter on the inner side, the outer margin usually turning rather abruptly inward at the junction of the neck with the venter; which is somewhat inflated, and includes nearly half the total length of the perithecium, which tapers distally to its broad stout rounded or subtruncate extremity. Perithecium 45–50 × 20–22 μ; the basal and stalk-cell regions about 28 × 18 μ. Axis of the appendage, including stalk-cell, 35–40 × 15 μ; the longer branches 30 × 6 μ. Receptacle, including foot, 30–34 × 18 μ. Total length to tip of perithecium 90–112 μ.

On *Trogophloeus* sp., No. 1471, Baños de Apoquindo near Santiago, Chile.

This species is closely allied to *C. Trogophloei* Speg. and *C. pusillus*, as well as to the two following species, all of which occur on similar hosts, and are characterized by the flattened cells of the axis of the appendage above the antheridial segment, which are separated by indentations and dark septa. It resembles Spegazzini's species in its general form and the suffusion of the subbasal cell; but differs in its smaller size, branched appendage and much less conspicuously tapering perithecium. The hosts were found swarming under stones in a mountain stream, in company with a larger form on which the following species was parasitic.

Cantharomyces Chilensis nov. sp.

Unevenly tinged with dark smoky brown, the basal cell and the stalk of perithecium paler. Receptacle somewhat geniculate, short, the basal cell darker above, its posterior wall somewhat blackened in connection with the foot, broader distally; subbasal cell mostly somewhat shorter, subtriangular, the walls, especially the posterior, very dark blackish brown. Appendage short and very broad, its outer walls very dark blackish brown, the stalk-cell usually broader than long, its inner upper angle rather conspicuously blackened; the antheridial segment usually slightly larger and somewhat convex on either side, somewhat oblique above and below, the outer margin shorter, the antheridial region usually on the right; the rest of the appendage consisting of a very broad flat dark cell, lying almost opposite the base of the ascigerous region, sometimes followed by a second smaller one; the cell above dividing several times vertically or obliquely, its divisions proliferating to form an irregular group of short, simple, stout, hyaline branches of variable length and divergence, sometimes ten or more in number. Perithecium and its stalk similar to that of *C. Andinus*, the basal cells about equal, darker than the pale stalk, but lighter than the dark smoky brown body; which is subtended on either side by more deeply blackened areas of the wall; the apex nearly hyaline. Spores about 28 × 3.5 μ. Perithecium average 70 × 30 μ: the stalk- and basal cell region 35–42 × 20 μ. Appendage, to tips of branchlets, longest, about 65 μ, the axis, including stalk-cell, 35–42 × 18 μ. Receptacle, including foot, 32 × 20 μ. Total length to tip of perithecium 110–130 μ.

In various positions on *Trogophloeus* sp., No. 1474, Baños de Apoquindo, Chile.

This species, which is distinctly larger than the last, although it is closely allied to it, differs in the absence of any contrasting blackening of the subbasal cell, in its general dark smoky brown color and especially in the characters of its very broad appendage.

Cantharomyces Valdivianus nov. sp.

Basal cell of the receptacle bent, sometimes at right angles to the subbasal, of nearly uniform width, nearly hyaline or faintly brownish, distally involved by the opaque suffusion of the subbasal cell, the upper somewhat oblique margin of which, and a small portion of the anterior wall near the base, are translucent brown; the cell straight, long-obconical, or cornucopia-shaped. Appendage slightly divergent, the stalk-cell somewhat broader than long, pale brownish, the walls of the upper half deep brown; the antheridial segment squarish, slightly narrower, uniform yellowish brown, externally slightly convex; the antheridial region usually external and lateral (right); the rest of the appendage consisting of from five to eight flattened concolorous cells, separated by constrictions and darker brown septa, one to three of the terminal cells producing short simple stout branches, of which there may be as many as six, two or three of which may arise side by side from the terminal cell. Perithecium and its stalk erect, or somewhat divergent, similar to that of the preceding species, but longer; the basal cells clearly defined, yellowish, narrower than the base of the concolorous perithecium; the venter symmetrically inflated, the junction of its wall-cells with those of the tapering neck portion indicated by a brownish shade; the tip rather well differentiated, relatively long, tapering very slightly; the apex very short, rounded and pale. Spores about $39 \times 3\,\mu$. Perithecium $55–70 \times 18–20\,\mu$. Stalk and basal cell region about $50 \times 18\,\mu$. Main axis of appendage $50–70\,\mu$, longer terminal branches $42 \times 7\,\mu$; antheridial segment $17 \times 19\,\mu$. Total length to tip of perithecium $125–175\,\mu$. Receptacle $60 \times 28\,\mu$, distally $\times\ 8\,\mu$ at base, the subbasal cell, average $50\,\mu$ long.

On various parts of *Trogophloeus* sp., No. 1901, Corral, Chile.

This species, which is much larger than the two preceding, is more nearly allied to *C. Trogophloei* Speg., from which it differs in its elongate opaque subbasal cell, and in the characters of its appendage. The symmetrical form of the perithecium is similar, but the tip is less abruptly distinguished and relatively stouter. The host was found in wet refuse caught against stones in a brook.

Cantharomyces Magellanicus nov. sp.

Basal cell nearly hyaline, about twice as long as broad separated by a slight abrupt constriction from the subbasal; which is short, abruptly three or four times as broad, irregularly cup-shaped, brownish yellow, deeper brown below and externally where it is strongly convex and separated by a constriction from the stalk-cell of the appendage; which is somewhat broader than long, externally strongly convex, concolorous, a deeper brown area let into the distal walls: antheridial segment abruptly somewhat narrower, externally prominent above, paler, the antheridial area external and on the left; the rest of the appendage short, tapering considerably, consisting of three (? always) cells, the upper prolonged into a short, cylindrical, blunt termination. Stalk of perithecium yellowish, elongate, uniform, the walls thicker than the lumen above; the basal cell region short, rather abruptly spreading; the perithecium somewhat asymmetrical, tinged with brown, somewhat inflated, the apex ending in a short blunt projection directed inward at right angles, and subtended externally by a somewhat shorter, broader blunt projecting cell which lies partly on the right. Perithecium, including basal cells, about 100 × 40 μ, the stalk 120 × 15 μ. Appendage about 70 μ, the stalk-cell 28 × 18 μ, the antheridial segment 22 × 20 μ. Basal cell of receptacle 16 × 8 μ, subbasal cell 14 × 25 μ. Total length to tip of perithecium about 225 μ.

On a small yellowish aleocharid staphylinid, at the tip of the abdomen. No. 1454, Punta Arenas, Magellanes, Chile.

I have described this form with much reluctance, owing to the fact that the material is limited to two very young and a single mature individual in which one of the two perithecia which were originally present, has been broken off, and the other has ceased to function and become bent upon itself, although its peculiar characters are clearly determinable. As the chances of its rediscovery in this remote region are slight, and in view of its very striking peculiarities, I have felt that it was safe to assume that it can be easily recognized, should it be found again. The form of the receptacle, the very elongate perithecial stalk, and the peculiar projections from the apex of the perithecium, are quite sufficient to separate it.

Monoicomyces Zealandicus nov. sp.

General habit short and compact, usually symmetrical. Basal cell minute, tinged with brown, the subbasal even smaller, hyaline, hardly distinguishable. Basal cell of the primary appendage nearly as large as the basal cell and foot, olivaceous brown, somewhat rounded in outline, bulging on the posterior side and lying below the black insertions of the perithecial stalks; the rest of the appendage bent inward, short, simple, hyaline, slightly tapering; consisting of about three or four cells, slightly longer than broad. Perithecia normally two, seldom three, paired, subtended externally by corresponding antheridia; the stalk-cells hyaline, narrow above their black insertions, broad distally, about as long as the primary appendage; basal cell region broad, the cells flattened; perithecium subsymmetrical, pale yellowish, the lower half considerably inflated; the distal tapering; the tip distinguished by a slight depression; the apex blunt, with very minute projections on either side. Antheridia brown, dark blackish olivaceous externally, the margins nearly opaque below and almost meeting between the basal and subbasal cells; compact, broad, the margins and termination rather strongly convex; the two terminal appendages shorter than the antheridia, erect, broader above; their close set, narrow insertions, dark blackish olive, the terminations usually hyaline. Perithecium 50–60 × 20–22 μ, the stalk-cell 18–25 × 10 μ, distally. Antheridium 35 × 16 μ, its appendages, longest, 32 × 5 μ. Total length 95–108 μ, greatest width 40–50 μ.

On the abdomen of *Atheta* (*Acrotona*) *Fungi* Graoh. (fide Dr. Fenyes), No. 2196, and on the abdomen and legs of somewhat larger form, No. 2197, Aukland, New Zealand.

This species is very closely allied to *M. nigrescens* which it resembles in general form and coloration. It seems to be clearly distinguished by the form of its antheridia, which lack the peculiar wedge-shaped outline of this species, the termination being convex instead of flat or concave. The perithecia are somewhat shorter and stouter, the antheridial appendages shorter, as is the stalk-cell of the perithecium. The broad brown basal cell of the primary appendage, which replaces the narrow black insertion of the appendage in *M. nigrescens*, is also quite different.

Eudimeromyces nov. gen.

Male individual, consisting of three superposed cells terminated by a single simple antheridium.

Female individual. General structure as in *Dimeromyces,* a basal cell followed by a small number of receptacle-cells, which pass without abrupt differentiation into a filamentous sterile appendage. Perithecium single in the type, arising from one of the lower cells, the walls of its basal and stalk-cells becoming entirely obliterated.

Were the antheridia of this type compound, its reference to *Dimeromyces* would hardly be doubtful, owing to the characters of the female which conform in general to this generic type, although there are no secondary sterile appendages, and the primary appendage is not differentiated from the receptacle, as is usually the case in *Dimeromyces*. In the male, however, the antheridium is terminal, not lateral, and is definitely simple and solitary.

Eudimeromyces Chiliotis nov. sp.

Male individual. Hyaline, slender, the three cells nearly uniform in length and width, the antheridium tapering, its neck and venter about equal in length. Total length including foot 25 × 4 μ. Antheridium 12 μ.

Female individual. Hyaline. Receptacle consisting of a basal cell and usually four additional cells somewhat transversely disposed. The basal cell slightly tinged with brownish, the subbasal larger than the others and prominent above the insertion of the perithecium, associated with a second cell finally nearly as large, and separated from it by division; the perithecium arising from the next much smaller cell: the fourth cell similar and obliquely separated from it, the basal cell of the appendage not otherwise distinguished, but larger and longer, the axis of the appendage simple, tapering, variably developed. Stalk of perithecium thick-walled, tapering somewhat below, not differentiated from the body of the perithecium; which is broader distally, nearly symmetrical; the tip and apex short and tapering to a broad truncate, or slightly rounded, symmetrical termination. Spores about 20 × 2.6 μ. Perithecium, including stalk, 65–75 × 14–15 μ. Receptacle 14–17 × 11–13 μ. Appendage, longer, 110–120 × 8 μ. Total length to tip of perithecium 80–100 μ.

On the elytra of *Chiliotes formosus* Reit. No. 1473, Baños de Apoquindo and No. 1898, Corral, Chile.

Sufficient material of this minute form has been examined, which shows but slight variations, principally in size. The perithecium appears to originate either at the right or left, its origin being somewhat misplaced by the growth of the two larger cells of the receptacle which are vertically elongated and lie side by side; the inner or third cell overlapping the fourth, which bears the perithecium. A somewhat similar condition of the receptacle is seen in species of *Dimeromyces* like *D. appressus*.

Herpomyces Chilensis nov. sp.

Male individual: copiously four or five times branched, the branchlets bearing terminally long, usually curved, slender antheridia, about 18 × 2 μ. Total length about 65 μ; width of tuft in large specimens 50–65 μ.

Female individual. General characters like those of *N. Nyctoborae.*

Secondary receptacles forming a row on either side of the primary insertion, adventitious receptacles arising behind them so as to form a group of sometimes more than ten; which are clearly distinguished, short and broad, somewhat spreading below, owing to a slight divergence from above downward, of the ten or twelve narrow vertical cells which form them; the basal and stalk-cell region distinguished by a more or less well defined constriction, short, variably prominent especially on the outer side owing to the convex margins ~~of the~~ somewhat bulging outer and inner cells, the region thus usually broader than the base of the venter, the perithecium as a whole very long and slender, its length about six times its greatest width, the ascigerous half tapering distally, the distal half narrow and more or less uniform in width; the two subterminal spines about equal and originating almost side by side. Perithecium above basal cells, to tip of terminal spine, 140–165 × 18 μ (ascigerous half) × 9 μ (distal half); spines, subterminal 30–32 μ, terminal 10 μ. Basal region 15–17 × 22–24 μ. Secondary receptacles 18–20 × 28–32 μ. Total length 175–220 μ.

On the antennae of a wingless roach, No. 1475, occurring under stones about the Baños de Apoqindo, Chile.

This form is very closely related to *H. Nyctoborae* of which it may prove but a variety. Abundant material of both species, however, shows constant differences, especially in the form and structure of the secondary receptacles which are much longer in *Nyctoborae*, the cells more numerous, very narrow and parallel; while in the present form they are short, relatively stouter, diverging slightly below, so that the receptacle has a slight fan shaped habit, and are at most ten or twelve in number. The length of the perithecium is much greater, and the slender terminal portion proportionately longer. The antheria appear to be more slender and slightly curved to form an appressed mass, but it has been impossible to determine the exact nature of the primary receptacle in either of the sexes.

Corethromyces Silphidarum nov. sp.

Uniform dirty yellowish throughout; habit straight, rather stout. Basal cell small, hardly longer than broad; subbasal cell twice as long, more or less, of nearly uniform diameter, somewhat obliquely separated terminally from the basal cell of the appendage: which consists of an axis which is repeatedly branched above the subbasal cell, some of the branchlets antheridial, their lower cells obliquely separated and becoming antheridia, the tuft of branches variably developed and seldom reaching beyond the tip of the perithecium. Stalk-cell of the perithecium subtriangular, lying beside and parallel to the subbasal cell, often extending slightly lower so that it is in contact with the basal cell; the secondary stalk-cell broad and rather large, obliquely separated from it; the basal cells small and not clearly defined. Perithecium straight, erect and symmetrical, or very slightly bent distally and more convex on the inner side; tapering slightly distally to the unmodified, rather blunt, flattish or rounded termination. Spores approximately 20 × 2 μ. Perithecium 50–65 × 15 μ. Appendage 50–60 μ, its basal cell about 10 × 7 μ. Receptacle 18–20 μ by 16–18 μ, including the stalk-cell of the perithecium. Total length 85–100 μ.

On the elytra of a small species of *Choleva*. Corral, Chile, No. 1495.

The appendages of this mondescript little form are usually so clogged with dirt, owing probably to the unclean habits of its host, that it is often difficult to make out the structure of the axes. In a few specimens many of the branchlets, which are variably developed, though sometimes copious, appear to conform to the normal type of the antheridial branchlets in this genus. It is most nearly allied to *C. bidentatus* and *C. curvatus* which occur on a similar host. Its appendage is very similar to that of the former, but it differs from both in the form of its straight erect perithecium, and the much greater elongation of the subbasal and perithecial stalk-cells.

Corethromyces curvatus nov. sp.

Color uniform pale yellow; rather short and stout, for the most part strongly curved. Basal cell hardly if at all longer than broad; subbasal cell and perithecial stalk-cell lying side by side, subequal. Appendage stout, its axis consisting of four or five cells; those above the basal producing distally on the inner side single, stout, rather short, slightly divergent branches, which may be once or twice branched, their lower cells short and broad, the lower more or less evidently united to the cells of the axis and branch above them, from which they are obliquely separated; the general axis thus appearing to be multicellular and relatively stout; the distal branches somewhat crowded. Perithecia strongly curved outward; the stalk- and basal cells clearly defined; the secondary stalk-cell usually smaller than the inner basal cell; the other basal cells more or less obsolete, or obliterated: body of the perithecium stout, the distal half tapering slightly, the outer margin nearly straight, the inner strongly convex; the short broad asymmetrical subtruncate apex broadly protruding externally, less broadly on the inner side, the smaller inner protrusion subtending an abruptly defined terminal papilla, which is thus not median. Spores about 24 × 2.5 μ. Perithecium 55–60 × 20–22 μ. Appendages, to tips of branches, 75–100 μ; longest branches 50–60 μ. Stalk and basal cell region 35 × 38 μ. Total length to tip of perithecium 75–95 μ.

At the base of the posterior legs of a species of *Choleva*. No. 2143b, Aukland, New Zealand. Messrs. Eames and Sinnott.

This species is most nearly related to *C. Silphidarum*, which occurs on a similar host, and to *C. bidentatus* with which it is associated. It differs from both of these species in the conformation of its perithecium and appendage, the somewhat massive character of the latter, which results from the union of the lower cells of the main branches to one another and to the cells of the axis, being quite different.

Corethromyces bidentatus nov. sp.

Uniform pale yellow, variably bent and curved. Basal and subbasal cells subequal, short. Axis of the appendage usually straight and suberect, consisting of usually three to five cells; the basal and subbasal large and appearing to bear terminally a tuft of branches, some of the branchlets of which consist of seriate antheridial cells. Perithecium divergent, curved outward and bent sidewise, as a rule; broader below, and tapering to the apex, which is more or less distinctly prominent on the inner side; thence tapering somewhat to a blunt pointed termination, which is subtended on the outer side by two short tooth-like projections, which diverge from the same point. Spores about 20 × 2.5 μ. Perithecium 52 × 15 μ. Appendage to tips of branches 55–65 μ. Total length 60–70 μ.

On the elytra of a species of *Choleva*. No. 2143, Aukland, New Zealand. (Messrs. Eames and Sinnott).

Although a considerable number of specimens of this form have been examined, a majority of them are injured or abnormal. The species is most nearly related to *C. Silphidarum*, from which it is at once distinguished by the two short divergent tooth-like projections which arise laterally from the apex.

Corethromyces bicolor nov. sp.

Foot broader than the base of the long slender obconical receptacle; which is opaque, the cell boundaries indistinguishable, except a small translucent portion just above the foot, its distal end asymmetrically furcate, owing to the presence of two blunt, hardly divergent lobes; one larger and longer, lying at the left and overlapping a portion of the venter; the other anterior, smaller and shorter, but otherwise similar. The perithecium usually bent at a slight angle to the axis, slightly inflated below, the region of the venter blackish olive, contrasting rather abruptly with the perfectly hyaline distal half or more; which tapers to the rather broad, slightly enlarged, somewhat rounded apex, from the middle of which a short blunt projection extends upward; the stalk-cell when partly visible, short, and hyaline. Appendage more or less concealed by the longer lobe, hyaline; consisting of a short axis with a few short hyaline branches on the inner side. Perithecium 50 × 16 μ. Receptacle to tip of longer lobe, including foot, 70–85 μ. Total length 110–124 μ, greatest width 20–24 μ.

On legs and inferior abdomen of a species of *Choleva*. Aukland, N. Z. No. 2143 (Messrs. Eames and Sinnott).

This very striking species, which belongs to the group that includes *C. Quedionuchi*, is at once distinguished by the coloration of its perithecium, and by its elongate, opaque, bilobed receptacle.

Corethromyces Valdivianus nov. sp.

Basal cell of the receptacle much elongated, funnel shaped, opaque, with a small translucent area above the foot; the blackening involving the inner portion, or sometimes almost the whole, of the subbasal cell as well as the outer half or more of the axis of the appendage; the inner walls remaining hyaline, one or two of the terminal cells usually not involved: subbasal cell of the receptacle obliquely placed, much flattened, its outer and sometimes its upper edge hyaline. Axis of the appendage consisting of five or six cells, tapering somewhat distally, and more or less distinctly curved toward the perithecium; the branches short and scanty, pressed against the venter. Stalk-cell of the perithecium hyaline or pale yellowish, oblique, somewhat rounded, much broader than long, forming, with the subbasal cell and the secondary stalk-cell, a paunch-like protrusion of this region, which is usually well marked; basal cells small, the region distinguished above the secondary stalk-cell by a rather abrupt depression. Perithecium straight, erect, or rarely very slightly divergent outward, the outer margin straighter: the venter-region more than twice as long as the rest of the perithecium in well developed individuals, hardly inflated, pale brownish yellow and uniform in width with the basal cell region: the neck-, tip- and apex-region concolorous, tapering; the apex very short, its small blunt extremity slightly roughened. Spores 45 × 3.5 μ. Perithecium 120–140 × 20–22 μ, including basal cells. Receptacle, to tip of axis of appendage, 100–120 μ; greatest width in region of paunch-like protrusion, 28–32 μ. Total length to tip of perithecium 190–225 μ.

At the tip of the abdomen of a species of *Quedius*. Corral, Chile. No. 1522.

This species is most nearly related to *C. atropurpureus*, the general form of the perithecium, which lacks any terminal modification, being similar. It is most readily distinguished by the paunch-like protrusion in the region of the perithecial stalk-cell, and the opaque suffusion which extends nearly to the tip of the axis of the appendage.

Corethromyces Andinus nov. comb.

Sphaleromyces Andinus Spegazzini. Revis. d. l. Laboul. Arg. p. 670. Ann. d. Mus. Nat. d. B. A. XXIX, 1917.

Abundant material of this species was obtained at Corral and Concepcion on *Quedius* sp., No. 1522. It appears to differ constantly from *C. Quedionuchi*, to which it is very closely related, in several characters. The opaque suffusion which, in the latter, does not quite extend to the upper edge of the basal cell, the upper limit of the suffusion being horizontal, or but slightly oblique, extends upward in the present species so that it involves not only almost the whole of the subbasal cell, but also the axis of the appendage nearly to its tip, its inner margin only, being hyaline or translucent. The axis of the appendage also diverges distinctly, and then curves toward the perithecium, the short hyaline branches being crowded against it. The conformation of the apex is also somewhat different, the outer lobe being more clearly distinguished, and not characterized by the even oblique curvature seen in that of *C. Quedionuchi*. In well developed specimens of *C. Andinus*, which may have a total length of 265 μ, the perithecium, above the basal cells measuring 150 × 22 μ, there is also a characteristic and deep external constriction just above the prominent and rounded secondary stalk-cell, not indicated in Spegazzini's figure, which appears to represent a rather small and not fully developed individual.

In addition to the species of *Corethromyces* above enumerated the typical form of *C. Stilici* was found at Corral, as well as two other species of which the material is not sufficiently good for purposes of description.

CUCUJOMYCES Spegazzini.

Abundant material of the three species of this genus described by Spegazzini (Revis. d. l. Lab. Argentin. p. 506) were obtained at Corral on *Hyliota Chilensis*, together with several other forms or varieties on this and other hosts. A single species has also been received from New Zealand which is herewith included, and still another from Kamerun which is not sufficiently mature for description. There are thus about ten species known, including **Cucujomyces elegantissimus** (Spegazzini sub *Stephanomyces*). The description of *Cucujomyces* which is given by Spegazzini appears to have been based on a misapprehension of the antheridial characters, since it is included by him in the Peyritschielleae, with which it does not appear to be even remotely connected. The compound antheridia, of a type approaching that of *Monoicomyces*, which he describes, are not present in any of the very numerous specimens of all ages that I have examined. Simple flask shaped antheridia of the normal type are, however, easily recognized in a majority of individuals, either borne terminally, sometimes on shorter, slightly specialized branches, as in *C. melanopus*, or more often variously disposed on secondary branchlets as in *C. elegans*. The affinities of the type seem to be rather with *Teratomyces* and *Symplectromyces*, and I was at first uncertain whether it might not better be referred to the latter genus. The primary receptacle in both these genera is, however, three celled, while in all the species of *Cucujomyces* it is two-celled; and for this reason, chiefly, it seems better that it should be separated.

The general structure which characterizes the species of the genus is as follows. The primary receptacle, consisting of a basal and a subbasal cell, is terminated by a primary appendage arising from the latter, which, in certain species or individuals, may give rise also to a subtending primary perithecium. In all species the subbasal cell further proliferates on either side to form corresponding secondary receptacles which grow acropetally in opposite directions, each consisting of a single series of cells which usually passes distally into an appendage-like termination. The cells of these receptacles may be so crowded that they appear to form a compact multicellular body, like that of Teratomyces; or they may grow out quite free on either side of the primary axis, sometimes curving backwards and meeting so as to form a more or less complete ring around the foot. Such strongly curved axes usually lie flat on the surface of the host the perithecia projecting upward from them. A variable number of the basal cells of these receptacles give rise to branches, and in a majority of cases, where their origin can be clearly seen, this branch seems to be single, its basal cell giving rise, however, either to secondary branches, which are usually those on which the antheridia are borne, or to perithecia, or to both. When the perithecium is mature, it thus usually appears to be subtended by the primary branch which it in reality subtends.

CUCUJOMYCES ELEGANS Speg.

What appears to be this species was found on the elytra of *Hyliota Chilensis* at Corral associated with all the other forms that occur on this host. The basal cell is more or less deeply tinged with brown; the insertion of the stalk-cell is black, the stalk itself is hyaline, or very faintly purplish, the perithecium pale purplish, but it is otherwise absolutely hyaline. I have separated the following form from it on account of its invariably blackened septa, purple or partly blackened perithecial stalk and somewhat different appendages, the cells of which are smaller, shorter and more numerous; usually separated by slight constrictions, the thin black septa edged below with faint purplish brown, suffusions. The appendages and their branches, which are more divergent and give the effect of dichotomy, are usually more numerous and rigid, but the form may be merely a variety or possibly a hybrid.

Cucujomyces intermedius nov. sp.

Similar to *C. elegans*. The basal cell slightly suffused; the perithecia similarly modified, the stalk purple, often dark, or the upper portion quite opaque; the primary and secondary branches and branchlets numerous, divergent, mostly rigid and but slightly if at all curved; the larger axes of both branches and branchlets composed of short, often bucket-shaped, cells, separated by more or less distinct constrictions and black thin septa, edged below with variably distinct purplish brown. Perithecia often subtended by a slight enlargement of the stalk, marked by transversed or slightly oblique purplish lines, the base often involved in the purple suffusion of the basal cell region; including the latter 38–45 × 16–18 μ; the stalk 175–300 × 12 μ. Longest branches 100–125 μ. Largest cells of the branches 8.5 × 7 μ or less.

On *Hyliota Chilensis*, Corral, Chile.

Cucujomyces stipatus nov. sp.

Basal cell relatively large, somewhat longer than broad, deeply suffused with brown; the subbasal cell smaller and obliquely divided into two cells, the upper of which forms the basal cell of the primary appendage and is distally prominent externally, its margin bending abruptly inward to the insertion of the free appendage, which is composed of eight or more flattened cells, separated by constrictions and blackish septa, two to four of the distal ones bearing short upcurved or rigid slightly divergent branchlets. Secondary receptacles more or less involved in the brown suffusion of the receptacle, their closely crowded cells forming with it a compact body, somewhat triangular in outline, which may be as a whole nearly opaque, the exact origins of the numerous branches and of the perithecia, several of which may mature, is hardly determinable; the bases of the secondary receptacles overlapping the basal cell somewhat and deeply blackened; the branches similar to the primary appendage above its basal cell, some terminating in an antheridium or bearing one or more short antheridial branches in addition to sterile ones. Perithecia bent more or less abruptly backward above the short hyaline portion of the stalk, the insertion of which is black, and which is succeeded by an opaque area that broadens distally and involves the secondary stalk-cell and the basal cell region, except its upper inner angle, and extends obliquely beyond the base of the perithecium. The latter slender, subcylindrical, or slightly inflated below, and tapering slightly to the extremity; the venter and neck regions not distinguished, and marked by more or less regular transverse purplish bands, which separate corresponding hyaline ridges that are variably evident; the tip long, clearly differentiated, often slightly inflated, purplish, tapering slightly to the very short apex which is bluntly rounded or subtruncate and distinguished only by its paler color. Spores about 35 × 3 μ. Perithecium, including opaque area, 100–130 × 18 μ. Longer appendages to tips of branchlets 50–70 × 5 μ. Total length 140–175 μ. Main body of receptacles about 50 × 28 μ, including foot.

On the elytra of *Hyliota Chilensis*. No. 1490, Corral, Chile.

This species is closely related to *C. cylindrocarpus*, and may prove only a compacted variety of this species, although its appearance is very different. The general form of its receptacles is very similar to that of species of *Teratomyces*, and the cells are so closely associated that the details of their arrangement are very difficult to determine. Its fundamental structure, however, is entirely similar to that of other species of the genus. The basal cells of the primary branches appear to produce secondary branches, or perithecia, on both sides. The antheridia are of the usual type and commonly terminal.

CUCUJOMYCES CYLINDROCARPUS Spegazzini.

This species was found in abundance at Corral on *Hyliota Chilensis*, and differs from the preceding form in its free normal secondary receptacles, which develop right and left in the usual fashion. The branches are entirely similar in general character, and the basal cell ordinarily produces a branch or rudimentary perithecium which may eventually develop, on both sides. The perithecium is similar, but more slender and cylindrical, its stalk hyaline, well developed and distally rather abruptly constricted below the small opaque area which subtends the perithecium and involves the small secondary stalk- and basal cells. The antheridia are similar in both cases.

CUCUJOMYCES MELANOPUS Spegazzini.

Numerous specimens of a form which appears undoubtedly to belong to this species were found for the most part on the antennae of *Hyliota Chilensis* at Corral, No. 1452 d, and although it does not correspond in all respects to Spegazzini's figure and description, its resemblances are too striking to be accidental. The banded perithecium with its opaque base and stalk-cell, as well as the hyaline bulbous base of the latter are entirely similar. The basal cell is colored, and forms a broad, free, rounded, tongue-like projection lying posterior to the subbasal cell; which bears not only the primary appendage and perithecium, as well as the usual secondary receptacles, but also certain accessory cells which give rise to branches or perithecia which are thus clustered in the mid-region so closely, that their origin is not easily determined. The primary branches are less distinctly fusiform than is represented in the figure just mentioned, and bear distally a smaller number of branchlets, seldom more than two or three, while there is not the slightest indication of a terminal compound antheridium such as Spegazzini describes. On the other hand there are present from two to six or seven specialized antheridial branches, which *arise in the mid-region, shorter than the primary ones, typically simple,* and bearing a single well marked terminal simple antheridium of the usual type.

Cucujomyces Diplocoeli nov. sp.

Basal cell of the receptacle dark translucent brown, distally spreading, but slightly overlapping the subbasal cell, which is rather small and normally gives rise to a primary perithecium and appendage; the latter rather stout, the basal and sometimes the subbasal cell often more or less swollen; consisting of usually six or seven cells, tapering somewhat distally. Secondary receptacles hyaline, usually four or five celled, with a tapering three- to four-celled termination, recurved and sometimes meeting to form a complete circle of cells around the foot: the branches hyaline, simple, relatively short, tapering and stout, one or more of the inner usually terminated by an antheridium, or bearing an antheridial branchlet subterminally; the basal cell giving rise to a secondary branch similar to the primary, or to a perithecium, several of which may develop, especially if the primary one is injured or aborted. Perithecium relatively large, the stalk-cell long, stout, rigid, straight or slightly curved, hyaline and often bulbous just above its hyaline insertion; otherwise opaque throughout, the opacity involving the inner basal cell; the broad, horizontal, somewhat irregular upper margin of which contrasts with the paler venter: the large secondary stalk-cell and the two small basal cells hyaline or paler; the region broader than the stalk-cell, and narrower than the venter, which is abruptly broader above it. Perithecium nearly symmetrical, broadest just below the mid-region, dark, rich yellow-brown, punctate-mottled, with a distinct tendency to a transverse arrangement; the distal half darker, almost truncate-conical; the flattish extremity hyaline-edged, with minute papillae on either side. Spores about 30 × 3 μ. Perithecium: stalk 100–220 × 7 μ, the bulbous base sometimes × 18 μ; basal cell region 14 × 18 μ; perithecium proper 50–56 × 20–28 μ. Appendages 35–70 × 5 μ.

On the elytra of *Diplocoelus* sp. No. 1897, Corral, Chile.

This species is most nearly related to *C. elegantissimus* and *C. melanopus*, both of which it resembles in its well developed opaque perithecial stalk. The simple antheridia are borne terminally, as a rule, as in *C. melanopus*, and the appendages are not unlike those of the last mentioned species, although they are simpler. It is probable that the appendages of *C. elegantissimus* are also similar, and bear terminal antheridia, but the detail of structure is not clearly shown in Spegazzini's figures. The perithecium, with its transverse mottling, is quite unlike that of either of these species. As a rule but one perithecium matures, but when the primary one is injured, or does not develop, the basal cell of the first appendage of both of the secondary receptacles develops one; and if these are injured, the appendages next in order develop one on either side, so that there may be as many as five present, perfect and imperfect. The development of the secondary receptacles varies considerably, since they sometimes form a disc-like mass in contact with the host, and surrounding the foot more or less completely, so that their true character may be almost or quite obscured.

Cucujomyces bilobatus nov. sp.

Basal cell uniform dark brown, distally somewhat concave and spreading to form two well defined lobes; subbasal cell overlapped by the basal, giving rise to a primary perithecium and appendage, the latter simple, tapering. Secondary receptacles forming a tapering axis, usually simple, turned backward and upward; two, or perhaps more, of the basal cells giving rise to primary branches, mostly simple with short antheridial branchlets, their basal cells proliferous on both sides to form secondary branches and perithecia. Stalk-cell of perithecium hyaline throughout, slightly broader toward the middle, the walls very thick, the lumen almost obliterated distally; secondary stalk-cell and inner basal cell small, about equal, lying side by side, separated from the end of the stalk-cell by a slight indentation and externally slightly convex; the region short, pale: the perithecium stout, slightly asymmetrical; the 'neck' region much darker than the venter, from which it is otherwise in no way distinguished; the tip and apex short, pale, tapering to a broad blunt extremity of evenly rounded outline. Spores about 25 × 2.8 μ. Perithecium; stalk 50 × 15 μ;

main body, including basal cell region, 54 × 22 μ. Appendages longest seen 50 μ. Axis of secondary receptacle to tip, longest, 60 μ. Spread of bilobed basal cell 18–22 μ.

On the elytra of a pale minute cryptophagid closely allied to *Cryptophagus*. No. 2198, Aukland, N. Z.

The material of this species is unfortunately very scanty, only one individual showing a fully developed perithecium. It is easily distinguished, however, from other known forms, by the character of its perithecium and stalk, and especially by the almost furcate basal cell. The basal cells of the primary branches appear to produce secondary appendages, or perithecial rudiments, on both sides, and this seems also to be true of the subbasal cell of the receptacle.

Cucujomyces curtipes nov. sp.

Basal cell tinged with brown, slightly broader than long, lying wholly below the subbasal, which gives rise to a primary perithecium and appendage: the latter tapering, shorter than the perithecium, the basal cell slightly larger: stalk-cell of the perithecium tapering somewhat from extremity to base, less than twice as long as broad, hyaline, its upper third or less opaque, distinguished below by a slight constriction, the region above the opacity, including the secondary stalk-cell, tinged with brown, abruptly somewhat broader, with symmetrically convex margins; the two smaller basal cells slightly prominent, surrounding the base of the ascigerous cavity: perithecium relatively large, uniformly tinged with dark brown, with a very faint indication of mottling, almost symmetrically broadly fusiform above the stalk-cell; distally truncate, or slightly pointed, somewhat darker; except the narrow hyaline distal margin, which is distinguished on either side by a minute papilla. Secondary receptacles straight, or but slightly recurved, diverging slightly downward, three of the basal cells usually producing the normal primary branches, which are closely grouped against the perithecium; the rest of the receptacle, the axis of which consists of four or five cells, producing two to four straight diverging branchlets, from one or both of the two terminal cells: the primary branches hyaline, rather stout, tapering distally, often ending in an antheridium, or with a subterminal short antheridial branchlet; the basal cells of the inner, at least, producing rudimentary perithecia which may develop. Spores 35 × 3.5 μ. Perithecium, stalk 18 × 10 μ; body, including basal cell region, 60–66 × 22–28 μ. Total length to tip of perithecium 95–105 μ. Primary branches, longest, 50 μ. Total length of secondary receptacles to tips of terminal branchlets, longest, 90 μ.

On the elytra of a minute dark species of *Liodes*, No. 1896, Corral, Chile.

This small species is well distinguished by its large short-stalked perithecium, the long black stalk of *C. Diplocoeli* to which it is most nearly related, being replaced by a small opaque area which subtends the perithecium. The close grouping of the primary branches about the perithecium, and the absence of branches from all but the last one or two cells of the rest of the secondary receptacles, gives it a characteristic habit.

Laboulbenia antarctica nov. sp.

Nearly uniform dull olive brown, becoming darker with age, the basal cell paler, the rest of the receptacle becoming obscurely punctate or mottled. Basal cell usually curved below, somewhat longer than the subbasal cell which is four-sided, often hardly longer than broad, separated by a slightly oblique septum from cell III; which is somewhat broader than long, its distal margin concave; cells IV and V of about equal length, the latter somewhat narrower; the stalk-cell (VI) very obliquely separated from cell II, somewhat smaller than cell III; the secondary stalk cell well defined, smaller, externally prominent. Perithecium rather stout, subsymmetrical, the wall-cells usually describing one quarter of a turn, so that a lateral view of the apex is presented; the main body somewhat broader distally, the black tip rather abruptly distinguished; the apex quite hyaline, contrasting, symmetrical when twisted, the distal margin broad and flat, the lateral lip-cells, which are anterior and posterior in position, ending in conspicuous, broad "valves" which occupy their whole distal margins. Insertion-cell rather thick, lying usually just above the lower fourth of the perithecium, which is free above it. Basal cell of the outer appendage hyaline, four or more times proliferous inward to form a corresponding crest-like series of branches radially placed; the short basal cell of each branch subtended by a thick blackened septum, usually proliferous and producing two or three branchlets radially arranged, more often simple, distinguished by thick black septa, rather long and slender, slightly tapering, hyaline, the lower septum usually black. Basal cell of the inner appendage much smaller, producing a branch on either side, the basal cell of which repeats the development of the outer appendage in general; being two to four times proliferous, the branches once or twice branched in a similar fashion, and bearing rather slender branches like those of the outer appendage or groups of rather densely crowded appressed curved brownish antheridia; these, or the sterile branchlets, variously predominating in different individuals. Spores about 35 × 3.5 μ. Perithecium 75–85 × 25–32 μ. Receptacle to insertion-cell 90–105 μ. Longest appendage 130 × 3.5–5 μ. Total length to tip of perithecium 150–175 μ; greatest width 40–45 μ.

Near the bases of the mid legs of ?*Antarctia* sp., No. 1452, Punta Arenas, Magellanes, Chile.

Several specimens of the host bearing this species were collected near the entrance to the ravine on the left bank of the Rio de las Minas above Punta Arenas. The species is very well characterized by the structure of its appendages, which recalls that of *L. orientalis*, except that they are less highly developed, and that a branch arises from both sides of the basal cell of the inner appendage. The appearance of the tip of the perithecium, which is usually, but not always, twisted one quarter, so that the anterior and posterior lip cells appear lateral, is quite peculiar, owing to the unusual development of the valves, which occupy the whole broad flat surface of these lips. A somewhat similar condition is present in *L. bidentata*, in which the valves, though narrower are even more prominent, and in several of the species which occur on Chrysomelidae.

Laboulbenia Andina nov. sp.

Olivaceous brown, darker below the perithecium; short and rather stout, the perithecium considerably longer and broader than the receptacle and basal cell region. Basal cell triangular, somewhat longer than broad, paler or hyaline, distally somewhat broader than the base of the somewhat smaller subbasal cell; which is distally pointed and obliquely separated from cells III and VI: Cell III broader than long, cells IV and V of nearly equal length, the latter separated by a vertical, or but slightly oblique, septum; the stalk- and secondary stalk-cells (cells VI and VII) nearly equal, obliquely separated, their combined outer margins rather prominently convex. Perithecium evenly inflated, or slightly asymmetrical, broader at the middle, or slightly above it, the very broad apex bluntly rounded without special modification, usually bent slightly outward. Insertion-cell dark olivaceous, the walls blackish; outer appendage simple, erect, tapering, short, its basal cell slightly longer than broad; the subbasal abruptly narrower, distinguished above and below by blackened septa, the lower oblique; the distal part consisting of one or two cells, hardly exceeding the middle of the perithecium: basal cell of the inner appendage but slightly smaller, bearing a short simple hyaline branch on either side, erect and appressed, without dark septa. Spores about 25 × 3 μ. Perithecium 65–70 × 24–28 μ. Appendages 28–35 μ. Total length 108–112 μ, to insertion cell 42 μ.

On the posterior legs of *Bembidium* sp. Baños de Apoquindo, Chile.

A minute and simple species distinguished by its olivaceous color, stout form, large pale basal and smaller narrower subbasal cell, and the black septa of its short simple outer appendage. The rather clearly defined walls have a more or less distinct reddish tint.

Coreomyces subdivisus nov. sp.

Uniformly pale brownish yellow throughout; straight, or but slightly bent; the perithecium almost exactly half the total length. Of the three basal cells, the subbasal, only, is usually slightly longer than broad; the third surmounted by from two to four flattened cladophorous cells, more often two, which are in turn followed by a large somewhat flattened cell, surmounted by two more cladophorous cells which subtend the perithecium; which is rather stout, erect, hardly inflated, the distal third or fourth curved outwards and sidewise, the stout bluntly and irregularly rounded apex being rather abruptly bent. Appendages copious, or usually broken off, rather stout, rigid, somewhat divergent, once or twice branched, the tips slightly tapering. Perithecium 80–88 × 28–30 μ. Total length 150–175 μ. Appendages, longest 125 μ.

On the mid inferior abdomen of *Corisa* sp. No. 1449, Concepcion, Chile.

This species appears to grow only on the middle of the inferior surface of the abdomen. It resembles *C. Corisae* in general appearance, but appears to be constantly distinguished by its smaller size, paler color, and the presence of cladophorous cells immediately below the perithecium as well as in the normal position.

Coreomyces acuminatus nov. sp.

Habit rather slender, subsigmoid, the axis consisting of three cells above which three to seven flattened cladophorous cells are distinguished. The stalk-cell above them but slightly longer than broad, wider distally; the perithecium pale brownish, the basal third slightly inflated, the rest slightly curved and tapering continuously to a pointed apex. Appendages scanty, rather short. Total length 210 μ, the lower axis × 16 μ. Perithecium 80 × 28 μ, its stalk-cell 20 × 22 μ, distally.

On the left margin of the upper surface of the abdomen of *Corisa* sp. Concepcion, Chile.

Unfortunately only one of several specimens of this species is fully matured, but all show the rather abruptly acuminate termination which appears to distinguish this species from others of the genus. It is more slender than *C. Corisae*, which was found abundantly in the same locality, and differs in its more or less sigmoid habit. The branches are mostly broken in the type.

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CONTRIBUTIONS FROM THE GRAY HERBARIUM OF HARVARD UNIVERSITY.

New Series.—No. LV.

I. Diagnoses and Notes relating to tropical American *Eupatorieae.*
II. A descriptive Revision of the Colombian Eupatoriums.
III. Keyed Recensions of the Eupatoriums of Venezuela and Ecuador.

By B. L. Robinson.

CONTRIBUTIONS FROM THE GRAY HERBARIUM OF HARVARD UNIVERSITY.— NEW SERIES, No. LV.

By B. L. Robinson.

Presented May 8, 1918. Received June 18, 1918.

I. DIAGNOSES AND NOTES RELATING TO TROPICAL AMERICAN EUPATORIEAE.

During the past year, in the course of further work toward a comprehensive treatment of the *Eupatorium* tribe, the following plants have been encountered, which appear to need description as novelties, readjustment of rank, or further record as to standing or synonymy.

Several types of new species and varieties here proposed are hitherto unclassified specimens (notably those of Triana, of Lobb, and of Kalbreyer) kindly lent to the writer some time ago from the Royal Gardens at Kew for investigation as opportunity permitted. These are indicated by the abbreviation (K.). For the privilege of examining and publishing upon others the writer is similarly indebted to the botanists of the New York Botanical Garden (N. Y.), the United States National Herbarium (U. S.), Missouri Botanical Garden (Mo.), Field Museum (Field Mus.), and University of California (Calif.). Plants in the Gray Herbarium are indicated by (Gr.). During the preparation of this paper much aid has been derived from photographs which the writer was permitted to take of types in European herbaria during his journeys in 1900, 1905, and 1910. In some cases fragments of types or authenticated specimens have been supplied to the Gray Herbarium in return for similar bits from types in this or other groups. Occasionally tracings or sketches have also been made. The nature of such reference material is briefly indicated by abbreviations which will be self-explanatory (phot., fragm., trac., sk., &c.).

The writer is specially indebted to Drs. H. H. Rusby & F. W. Pennell for the privilege of studying the Eupatoriums of their recent and extensive collection from Colombia. Dr. Rusby has also permitted the inclusion here of his *E. Squiresii,* a hitherto unpublished novelty discovered on an earlier expedition to Venezuela. Prof. N. L. Britton has aided the writer by the loan of valuable material and by information, from time to time as solicited, regarding specimens in the extensive herbarium of the New York Botanical Garden. He has furthermore brought to the attention of the writer a well marked and highly interesting novelty from Jamaica, *E. hammatocladum*, and has consented to join in its publication. Mr. W. R. Maxon of the United States National Museum has sent to the Gray Herbarium for study many *Eupatorieae* collected by himself in Panama, by Prof. H. Pittier in Costa Rica, Panama, Colombia, and Venezuela, and by Bros. Apollinaire & Arthur in the neighborhood of Bogotá. Mr. T. S. Brandegee has sent many Eupatoriums collected by Dr. C. A. Purpus, chiefly from Vera Cruz and vicinity. Prof. C. F. Millspaugh of the Field Museum has brought to the writer's attention and lent for study a small but interesting collection made by Dr. Arthur Schott in Colombia just south of the Panama boundary. Miss Mary A. Day, librarian of the Gray Herbarium, has assisted in the bibliography and proof-reading, and in tracing many minor geographic localities of which the correct placing has involved much discriminating search in maps, atlases, and works of travel of very different periods. Mr. Percy Wilson has most kindly contributed a detailed transcription of the field data accompanying the Eupatoriums and Mikanias of the H. H. Smith collection from the region of Santa Marta. To all these persons the writer wishes here to express his thanks and cordial appreciation of their valued aid.

Eupatorium (§ **Eximbricata**) **Apollinairei**, spec. nov., ut videtur herbaceum vel mollissime lignescens sordideque glanduloso-tomentosum; caule tereti medulloso valde flexuoso fortasse plus minusve scandente; ramis oppositis patentibus; foliis oppositis late ovatis obtuse acuminatis crenatis basi sinu angusto profundo cordatis a basi 5–9-nervatis supra subglabris subtus pallidioribus praecipue in nervis venisque glanduloso-tomentulosis 7–13 cm. longis aequilatis; petiolis subteretibus densissime glanduloso-tomentosis 3.5–7 cm. longis; corymbis terminalibus planiusculis pluricapitulatis; capitulis 7 mm. altis ca. 58-floris graciliter pedicillatis; involucri campanulati squamis ca. 24 subaequalibus lineari-lanceolatis longissime attenuatis dorso pubescentibus 3-nerviis subherbaceis viridibus; corollis albis 5 mm. longis, faucibus cylindricis 2.5 mm. longis, tubo proprio gracillimo 2.5 mm. longo, limbi dentibus 5 patentibus dorso longiuscule hispidis; achaeniis nigris 5-angulatis deorsum decrescentibus basi callosis in costis patenter hispidulis (pilis non glandulosis); pappi setis ca. 16 albis tenuiter capillaribus vix scabratis corollam subaequantibus basi in cupulam coroniformem connatis; styli ramis filiformibus; antheris apice cum appendice ovato-oblongo munitis basi distincte subsagittatis; receptaculo plano glabro.— COLOMBIA: near Bogotá, alt. 2700 m., *Bros. Apollinaire & Arthur*, no. 94 (TYPE Gr., dupl. U. S.).

This species in many respects closely approaches *E. viscosissimum* Rolfe, Gard. Chron. ser. 3, xxxix. 274 (1906), a plant of Lower California. It shows, however, a variety of minor differences which together with its very different habitat and widely separated range indicate clearly that it is to be regarded, at least for the present, as a distinct species. In *E. viscosissimum* the style-branches are strongly clavate, and the corolla has a throat distinctly exceeding the proper tube into which it passes very gradually, while in the present species throat and tube are the same length and the demarcation between them is rather sharp and definite. The achenes in *E. viscosissimum* have the ribs provided with ascending short bristles while in the present species the bristles are divaricate. Furthermore, the involucral scales in *E. viscosissimum* have the 3 nerves more or less branched in many instances, which does not appear to be the case in the Colombian plant. Somewhat nearly related is the Mexican *E. cardiophyllum* Robinson, but notwithstanding many points of resemblance it is clearly distinct, having fewer-flowered heads, leaves of firmer texture, and a glabrous corolla.

E. (§ **Subimbricata**) **arcuans**, spec. nov., fruticosum; ramis teretibus valde flexuosis glabratis, ramulis arcuatis angulatis ferrugineo-tomentosis; foliis parvis (1.5–3 cm. longis 1–1.5 cm. latis) oppositis petiolatis ovatis subacuminatis basi rotundatis supra mediam partem utroque 2–3-dentatis paullo crassiusculis vix membranaceis a basi conspicue 3-costatis supra subglabris cum nervis depressis, subtus olivaceis in nervis prominulentibus sparse pubescentibus; petiolo gracile ca. 5 mm. longo; capitulis 7 mm. altis; ca. 10-floris; involucri subcylindrici squamis ca. 16 sub-3-seriatis valde inaequalibus oblongis obtusis vel apice rotundatis 3–5-costatis obscure ciliolatis aliter glabris; corollis glabris 4 mm. longis, tubo proprio 2.4 mm. longo gracili, faucibus 1.3 mm. longis primo sensim ampliatis deinde paullo contractis; achaeniis glabris gracilibus 2.5 mm. altis.— "NEW GRENADA" without more exact locality, *Triana*, no. 1191 (TYPE K., phot. Gr.).

E. BALLOTAEFOLIUM HBK., Nov. Gen. et Spec. iv. 121 (1820). Study of the available Colombian material of this species discloses two pretty readily distinguishable varieties, which may be characterized as follows:

Var. **typicum**, involucri squamis lanceolatis modice firmis fere ad apicem costatis, exterioribus gradatim brevioribus et angustioribus.— Colombia: without precise locality, *Humboldt & Bonpland* (Par., phot. Gr.); also later collected by many others; see p. 321.

Var. **caucense,** var. nov., involucri squamis subaequalibus plerisque oblanceolatis apicem versus tenuioribus et magis herbaceis vix costatis dorsaliter magis pubescentibus; aliter var. *typico* simillimum.— *E. ballotaefolium* Hieron. in Engl. Bot. Jahrb. xxviii. 575 (1901), not exactly of HBK.— Colombia: in the upper Cauca Valley, under low isolated thickets on savannahs near Anserma Nueva, alt. 1000 m., *Lehmann,* no. 3279 (type Gr.); common in scattered bushy places on savannahs along the Rio Paez, *Lehmann,* no. 5675 (U. S.).

E. celtidifolium Lam., var. **hirtellum,** var. nov., arborescens 3–6 m. altum; inflorescentiae ramis et ramulis et pedicellis crispe hirtellis, pilis brevibus flexuosis; achaeniis non solum in costis sed etiam in faciebus hirtellis; aliter omnino ut apud var. *typicum* Antillum.— Colombia: Dept. Magdalena, locally common in dry forest near Bonda, below alt. 150 m., May, 1852, *L. Schlim,* no. 909 (K., phot. Gr.).

In the typical variety, as it grows in Martinique and Dominica, the subdivisions of the inflorescence are glabrous and the achenes are hairy almost exclusively on the ribs and very slightly if at all on the faces.

E. (§ **Eximbricata**) **chiriquense,** spec. nov., fruticulosum 2.5–3 dm. altum; caule fusco paullo decumbente vel suberecto fastigiatim dichotome vel trichotome ramoso; ramis erectis foliosissimis atropurpureis strigillosis infra post foliorum delapsum nudis fuscis nodulosis lignescentibus; internodiis 3–9 mm. longis; foliis oppositis subsessilibus ovatis 1–2.5 cm. longis 6–15 mm. latis acutatis vel acuminatis ad apicem verum obtusiusculum crenato-serratis subcoriaceis supra viridibus glabris rugulosis subtus vix pallidioribus in nervis venisque pubentibus a basi 3-nerviis; petiolo vix 1 mm. longo; corymbis ramos terminantibus multicapitulatis densiusculis 3–5(–8) cm. diametro convexis; pedicellis filiformibus longiusculis glandulari-pubescentibus; capitulis ca. 26-floris 9 mm. altis 8 mm. diametro; involucri campanulati squamis ca. 14 linearibus obtusis subaequalibus (1–2 extimis brevioribus exceptis) dorso glandulis minutis stipitatis praeditis; corollis ut videtur albis vel forsan roseis 5 mm. longis, tubo proprio 1.7 mm. longo, faucibus campanulatis distincte ampliatis 2.5 mm. longis, dentibus limbi 5 deltoideis 0.8 mm. longis; achaeniis atrobrunneis 2 mm. longis in costis hispidulis; pappi setis ca. 19 capillaribus vix scabratis 3.5 mm. longis roseis.— Panama: among rocks,

summit of Chiriqui Volcano, alt. 3374 m., *William R. Maxon*, no. 5360 (TYPE U. S.); dry sunny places, upper belt of Chiriqui Volcano, northern slope, alt. 3374 m., *Pittier*, no. 3089 (U. S.); on the same mountain but without number or indication of locality or altitude, April, 1899, *C. Sapper* (U. S.).

A characteristic and probably local species.

E. (§ **Eximbricata**) **choricephalum**, spec. nov., herbaceum perenne erectum 3–7 dm. altum; radice e fibris longis numerosis subsimplicibus nigrescentibus composita; caule pubescente gracili basin versus simplici superne laxe paniculatim ramoso; foliis suborbiculari-ovatis acuminatis grosse crenatis (dentibus 1.5–4 mm. altis 3–8 mm. basi latis) basi late cordatis ad insertionem petioli acuminatis membranaceis utrinque viridibus supra subglabris vel sparse hirtellis (pilis saepius adpressis) subtus vix pallidioribus in nervis venisque hirtellis ima a basi 3-nerviis 3–7.5 cm. longis 2.5–6 cm. latis; petiolo 1.5–3 cm. longo; panicula laxissima 4–6 dm. longa 2–3 dm. diametro foliaceo-bracteata; bracteolis lanceolatis parvis vel minimis; pedicellis filiformibus pubescentibus 8–18 mm. longis; capitulis dissitis ca. 34-floris 6.5 mm. altis 6 mm. diametro cymoso-dispositis; involucri campanulati squamis subaequalibus (una vel duabus multo minoribus) oblongo- vel lanceolato-linearibus acutis 4.5 mm. longis, exterioribus dorso villosulis, interioribus longiuscule ciliatis aliter subglabris saepius 2-costatis et 3-nerviis; corollis albis 3–4 mm. longis, tubo proprio gracili glabro 1.6–2 mm. longo, faucibus turbinato-subcylindricis 1.2–1.8 mm. longis extus sparse hirtis, dentibus limbi 5 (vel rariter 4) 0.3 mm. longis deltoideis obtusiusculis intus papillosis extus hirsutulis; antheris brevibus basi distincte sagittatis apice cum appendice ovato-oblonga munitis; achaeniis nigris 1.5–2 mm. longis in costis et etiam in faciebus hispidulis basi callosis apice cum disco cupulato coronatis; pappi setis ca. 28 albis 4 mm. longis paullo scabratis.— *E. grandidentatum*, var. *laxiflorum* Gray in Pringle, Pl. Mex. [list of 1886] on first (unnumbered) page, as a name only. *E. guadalupense* Gray ex Wats. Proc. Am. Acad. xxii. 421 (1887), not Spreng.— CHIHUAHUA: southwestern part, Aug.–Nov., 1885, *Palmer*, no. 276; shaded ravines, Mapula Mts., 30 Oct., 1886, *Pringle*, no. 747. DURANGO: *Palmer*, no. 857. JALISCO: shaded hillsides, Chapala, 1886, *Palmer*, no 712; ravines near Guadalajara, 14 Oct. 1903, *Pringle*, no. 11,924 (TYPE Gr.). MICHOACAN: oak woods near Uruapan, alt. 1464 m., *Pringle*, no. 10,099. MORELOS: barranca near Cuernavaca, alt. 1982 m., 23 Nov. 1902, *Pringle*, no. 11342. VERA CRUZ: Orizaba, *Botteri*, no. 494.

This is the plant which has in recent years been passing as *E. Muelleri* Sch. Bip., the identity of which is discussed below.

The plant here described as *E. choricephalum,* although for many years well represented in herbaria, appears never to have been characterized. Dr. Gray evidently glimpsed the plant as a separable entity and gave it a manuscript name as a variety of *E. grandidentatum* DC., but he may have lost confidence in it or altered his conception of *E. grandidentatum* (which has subsequently proved a synonym of the older *E. pazcuarense* HBK.), for he never published a description of this variety.

Dr. Gray's varietal name, *laxiflorum,* notwithstanding its morphological inaccuracy, as well as its lack of characterization and consequently negligible nature, would have been here taken up in the specific rank, except for the circumstance that it would have necessitated making Pringle's no. 747 the type of the species, since it would have been the type of the name-bringing synonym. It happens, however, that this particular number, while pretty clearly conspecific with the others here referred to the new species, is by no means central or typical among them, being in fact a little firmer in general texture and having slightly more rigid pedicels. It therefore seems ill-fitted to function as the type of the group (otherwise pretty uniform) in which it seems a trifle exceptional.

E. (§ **Cylindrocephala**) **chrysostictum,** spec. nov., scandens vel in frutices vicinos incumbens 3–3.6 m. altum perenne vel fruticosum subglabrum, caule tereti laevi; internodiis 8 cm. vel ultra longis; foliis oppositis petiolatis ovatis caudato-acuminatis basi rotundatis margine revolutis subintegris (denticulis minimis obscuris callosis ca. 5–7 mm. distantibus instructis) usque ad 10 cm. longis 5 cm. latis a basi 3-nerviis et cum nervulis intramarginalibus undulatis munitis supra laevissimis lucentibus laete viridibus subtus vix pallidioribus glabris cum punctis aureis numerosis translucentibus instructis, venis inter costas subregulariter transientibus; petiolo gracili 1–1.5 cm. longo glabro; panicula 3–4 dm. longa 1.5–2 dm. diametro foliaceo-bracteata oppositiramea; ramis divaricatis ca. 8–10-capitulatis, pedicellis plerisque 1 cm. longis patentibus paullo sulcatis minutissime papillosis; capitulis ca. 12 mm. altis ca. 26-floris 7 mm. diametro; involucri cylindrici 9 mm. alti squamis ca. 37 oblongis 3–5-nerviis obscure ciliolatis apice rotundatis mucronulatis stramineis apicem versus viridescentibus; corollis albis vel pallide purpureis glabris 6 mm. longis graciliter tubulosis a basi ad limbum plerumque 4-dentatum sensim ampliatis sine faucibus distinctis; achaeniis 3.5 mm. longis gracilibus deorsum paullo decrescentibus in costis obscure subremoteque papillosis; pappi setis ca. 40 stramineo-albidis 5.5 mm. longis.— COLOMBIA: Las Nubes near Santa Marta, alt. 1372 m., 7 Feb., expedition of 1898–'99, *H. H. Smith*, no. 660 (TYPE Gr.).

A species which appears very clearly distinct in habit and many technical characters from any previously attributed to Colombia. Said to be common in thickets near streams, alt. 1220–1830 m.

E. CONYZOIDES Mill. Dict. ed. 8, no. 14 (1768). Although this species is by Hooker f. & Jackson, Ind. Kew. i. 916 (1893), referred to *Vernonia arborescens* (L.) Sw., it is entirely clear from Miller's description stating that the leaves were 3-nerved and hastate in form, as well as by his reference to the "*Conyza fruticosa, folio hastato, flore pallide purpureo*" of Sloane's Cat. Jam. 124, that the plant he had in mind was certainly not *Vernonia arborescens* (L.) Sw., which has lance-oblong essentially entire pinnately veined leaves. Both from Miller's description and from his direct reference to Sloane, who in his turn cites Plukenet's plate 177, fig. 3, which forms the primary basis of the Linnaean *E. odoratum*, there is no reason to suppose that Miller's *E. conyzoides* was other than *E. odoratum* L., as was the later *E. conyzoides* of Vahl.

E. (§ **Eximbricata**) **cuencanum,** spec. nov., herbaceum perenne decumbens gracile usque ad inflorescentiam glaberrimum; caule tereti purpureo-brunneo laevissimo flexuoso ca. 3 dm. alto apice trichotomo-cymoso; foliis oppositis ovatis cordatis ad apicem obtusiusculum angustatis serrulatis firmiuscule membranaceis 2–2.5 cm. longis 1.2–1.6 cm. latis a basi 3(–5)-nerviis in siccatione fuscescentibus; petiolo gracillimo 8–10 mm. longo; inflorescentiae ramis pedunculisque cum glandulis atropurpureis stipitatis munitis aliter glabris; capitulis paucis laxissime cymosis ca. 7 mm. altis 3–4 mm. diametro 16–19-floris; involucri anguste campanulati squamis lanceolato-linearibus ca. 18 ca. 5 mm. longis acutis vel paullo erosis non ciliatis dorso 2-costatis 3-nerviis cum glandulis paucis stipitatis munitis; receptaculo parvo plano glabro; corollis ut videtur albis 3.5 mm. longis in limbo 5-dentato extrorsum paullo villosulis, tubo proprio 1.7 mm. longo fauces cylindricas mediocriter ampliatas aequante; achaeniis pallide brunneis glaberrimis 3 mm. longis basi callosis apice cum disco coronatis; pappi setis ca. 14, 3.5 mm. longis fragilibus caducis basi brevissime connatis.— ECUADOR: Cuenca, *Sallé*, communicated to the herbarium at the Kew Gardens by Mr. W. W. Saunders, Oct. 1874 (TYPE K., trac. Gr.).

A species with the habit of *E. gracile* HBK., *E. caducisetum* DC., and

E. epilobioides HBK. but differing from all these in its more cordate leaves and particularly in the presence of numerous tack-like glands on the inflorescence, the plant being otherwise entirely glabrous.

E. (§ **Cylindrocephala**) **diaphanophlebium,** spec. nov., *E. chrysosticto* habitu glabritate simillimum; caule gracili tereti 2.5 m. alto; foliis oppositis ovatis apice caudato-acuminatis basi rotundatis 5–7 cm. longis 2.8–3.5 cm. latis paullo supra basin 3-nervatis margine paullo undulatis obscure subremoteque calloso-denticulatis utrinque viridibus subtus paullulo pallidioribus impunctatis sed pulcherrime pellucido-reticulatis; panicula ca. 2.5 dm. longa 1.5 dm. diametro foliaceo-bracteata oppositiramea, ramis trichotomis multicapituliferis; capitulis ca. 8 mm. altis 4 mm. diametro; pedicellis 1–5 mm. longis sulcato-angulatis; involucri graciliter cylindrici ca. 6 mm. alti squamis ca. 25 oblongis 3–5-nerviis 4–5-seriatim imbricatis ciliolatis apice rotundatis; corollis 4 mm. longis glabris cum tubo proprio ca. 1 mm. longo et faucibus vix ampliatis cylindraceis; achaeniis 2.5 mm. longis glabris et etiam in costis laevibus; pappi setis ca. 35 albidis capillaribus vix scabratis.— COLOMBIA: in thicket, Las Nubes near Santa Marta, alt. 1372 m., expedition of 1898–'99, *H. H. Smith*, no. 1990 (TYPE Gr.).

A species at first sight suggesting a possible small-headed form of *E. chrysostictum*, but clearly distinct through a variety of characters not likely to be intergradient, as, for instance, the impunctate leaves with pellucid veins, the much more extensive branching (attaining to the third and fourth order) of the panicle, etc.

E. (§ **Conoclinium**) **diplodictyon,** spec. nov., verisimiliter herbaceum; caule tereti flexili ca. 4 mm. crasso fusco-tomentoso, pilis patentibus articulatis; foliis oppositis graciliter (1.5–3.3 cm. longe) petiolatis deltoideo-ovatis longiuscule acuminatis dentatis (dentibus ca. 3 mm. altis ca. 5 mm. latis saepe plus minusve denticulatis) basi profunde sinu angusto sed non clauso cordatis 7–10 cm. longis 4–6.5 cm. latis a basi 3–5(–7)-nerviis utrinque prominulenter reticulatis lucidulis laete viridibus supra glabriusculis vix in venis hirtellis subtus in venis venulisque laxius pilosis; corymbo terminali densiusculo valde convexo ca. 7 cm. diametro ad 1 dm. longe pedunculato, ramulis pedicellisque fusco-tomentellis, pilis et articulatis et glanduloso-capitatis; capitulis ca. 30-floris 13 mm. altis; pedicellis ca. 7 mm. longis; involucri campanulati squamis ca. 13 lanceolatis herbaceis striatulis acute acuminatis 7 mm. longis dorso patenter pilosis; receptaculo distincte conico apicem versus rudimenta flosculorum aliquorum abortivorum gerente; corollis 5.5 mm. longis glaberrimis, tubo proprio 3 mm. longo sensim in fauces 2.5 mm. longas ampliato, dentibus limbi 5 ovato-lanceolatis patentibus 0.7 mm. longis; achaeniis stramineo-olivaceis 2.8 mm. longis lucidulis deorsum decrescentibus angulis praesertim apicem versus sparse hispidulis, faciebus nigro-punctatis; pappi setis ca. 40 stramineo-albidis 5.5 mm. longis vix scabratis.— COLOMBIA: *Lobb* (TYPE K., phot. Gr.).

A species obviously related to *E. lamiifolium* HBK. of middle altitudes on the Ecuadorian Andes, which, however, has considerably smaller heads with more numerous and very unequal involucral scales of much smaller size. Its leaves are, furthermore, rugose above and very shallowly cordate instead of being penetrated by a deep narrow sinus as in the species here described. Unfortunately the specimen is accompanied by no data in regard to the precise locality, habitat, habit, or flower-color.

E. (§ **Eximbricata**) **droserolepis**, spec. nov., herbaceum vel paullo lignescens subglabrum exsiccatione fuscescens; caule subtereti gracili leviter costato-angulato superne oppositirameo primo purpureo-fusco maturitate griseo-brunneo; foliis oppositis graciliter petiolatis ovato-lanceolatis caudato-acuminatis basi rotundatis vel subcordatis grosse serratis vel undulato-dentatis utrinque glabris viridibus obscuris opacis subtus paullo pallidioribus nigro-punctatis 5–7 cm. longis 2–4 cm. latis a basi vel vix supra basin 3(–5)-nerviis apicem versus saepe falcatis; petiolo 4–12 mm. longo; bracteis foliaceis gradatim reductis lanceolatis petiolatis, supremis linearibus minutis sessilibus; panicula ampla 1–3 dm. alta et crassa laxe ramosa; pedicellis filiformibus sub lente obscure puberulis 5–25 mm. longis; capitulis ca. 11-floris 8 mm. altis; involucri squamis ca. 10 lineari-oblongis laxe imbricatis obtusis 1-costatis subcarinatis ad 5 mm. longis margine sub lente obscure eroso-fimbriatis dorso cum glandulis lucidis globosis sessilibus dense obsitis, extimis paucis brevioribus; corollis 3.5 mm. longis sursum a media parte gradatim ampliatis, dentibus limbi brevissimis recurvatis; styli ramis longis filiformibus recurvatis fuscis apice brevissime incrassatis; achaeniis 3 mm. longis primo sursum in angulis hispidulis sed maturitate glabratis non glanduliferis nigrescentibus; pappi setis ca. 37 sordidis inaequalibus basi subconnatis sursum scabratis.— PORTO RICO: summit of Monte Torrecilla, alt. 1100 m., 19–20 March, 1915, *N. L. Britton, J. F. Cowell, & S. Brown*, no. 5608 (TYPE N. Y., phot. Gr.); Utuado, 8 November, 1913, *F. L. Stevens & W. E. Hess*, no. 4575 (N. Y., phot. Gr.).

E. (§ **Hebeclinium**) **erioclinium**, spec. nov., ut videtur herbaceum elatum; caule tereti fulvido-tomentello medulloso; foliis oppositis suborbiculari-ovatis magnis acuminatis crenato-dentatis basi rotundato-truncatis vel subcordatis integriusculis 14–16 cm. longis 10–12 cm. latis membranaceis utrinque glabriusculis in nervis venisque fulvo-tomentellis prope basin cum 2 jugis nervorum munitis supra basin palmatim 3-nervatis; petiolo 3.5–5.5 cm. longo; paniculis amplis terminalibus et lateralibus ovato-pyramidalibus trifidis laxiusculis usque ad 2 dm. altis et crassis multicapitulatis; capitulis ca. 20-floris subsessilibus in glomerulos subsphaericos collectis; involucri campanulati 2 mm. longi squamis ca. 16 ovato-oblongis valde inaequalibus obtusis vel apice rotundatis 3–4-costatis ciliatis; receptaculo valde convexo densissime niveo-villoso, pilis 0.6–0.8 mm. longis erectis; corollis graciliter cylindraceis sine faucibus distinctis breviter 5-dentatis 3 mm. longis limbum versus paullo hispidulis ut videtur albis; styli ramis longissimis gracillimis filiformibus; achaeniis nigris glabris 5-costatis deorsum decrescentibus 1.3 mm. longis basi callosis; pappi setis 30–35 albis tenuiter capillaribus.— COLOMBIA: occasional in thickets near water at Las Nubes, near Santa Marta, alt. 1373 m., 15–20 Dec., *H. H. Smith*, no. 625 (TYPE Gr.).

A species with the habit of *E. guapulense* Klatt, to which it is very close in many of its characters. In that species, however, the stem is described as notably tetragonal, the leaves are more distinctly cordate at base and are 3-nerved from the very base instead of being provided with two pairs of pinnately disposed nerves before the palmate divergence of the three principle nerves which occurs no less than 1.5–2 cm. above the actual base of the leaf. If one may judge from description as well as from an excellent photograph of the type of *E. guapulense* in the Gray Herbarium, the leaves in that species are somewhat thicker and are covered with more copious pubescence.

E. (§ **Eximbricata**) **flavisetum,** spec. nov., fruticosum; caule tereti firme lignoso cum cortice griseo-brunnescente tecto; ramis suberectis flexuosis conspicuiter nodosis; ramulis foliosissimis cum pilis setiformibus patentibus fulvo-flavidulis densissime instructis, foliis oppositis brevissime petiolatis ellipticis subcoriaceis utroque obtusis vel rotundatis crenato-serratis 3–3.5 cm. longis 1.3–2 cm. latis utrinque crebre reticulatis (venulis prominulentibus non sulcatis supra sparse subtus copiose setosis; petiolo 1–3 mm. longo dense setoso; corymbis terminalibus folia subtendentia vix superantibus parvis (2–3 cm. diametro) paucicapitulatis; pedicellis brevibus tomentoso-setosis; capitulis ca. 7 mm. altis et 5 mm. diametro ca. 14-floris; involucri campanulati paullo imbricati 1–2(–3)-seriati squamis lanceolatis dorso pubescentibus; corollis verisimiliter purpurascentibus glabris 5 mm. longis; tubo proprio 2 mm. longo leviter gradatimque in fauces 3 mm. longas ampliato; antheris apice cum appendice brevi obtusa vel retusa munitis; achaeniis 3.5 mm. longis deorsum decrescentibus in faciebus et praesertim in angulis hispidulis; pappi setis ca. 31 inaequalibus plerisque ca. 5 mm. longis paullulo rigidiusculis flavidulo-albidis.— "VENEZUELA &c.," coll. of 1842–3, *Funcke*, no. 520 (TYPE K., phot. Gr.).

E. (§ **Eximbricata**) **glischrum**, spec. nov., fruticosum ramosum; ramis teretibus oppositis flexuosis nodosis atrogriseis; ramulis pappilloso-scabridulis atropurpureis; foliis oppositis oblongo-lanceolatis breviter petiolatis obtusis leviter cuspidatis basi cuneatis integerrimis trinerviis (nervis lateralibus anastomosantibus) utrinque glabris et vernicosis 2–3.5 cm. longis 5–10 mm. latis, levissime reticulatis subtus paullo pallidioribus, petiolis 2–6 mm. longis; inflorescentiis dense cymosis 2–3 cm. diametro terminalibus vernicoso-viscosis oppositirameis; capitulis 4–6-floris sessilibus vel brevissime pedicillatis 1 cm. altis; involucri subcylindrici squamis ca. 7 subaequalibus anguste oblongis obtusis 4.8 mm. longis apicem versus eroso-ciliolatis dorsaliter convexis 2–3-striato-nervatis marginibus valde involutis; corollis purpurascentibus glabris 5.5 mm. longis, tubo proprio ca. 1.5–2 mm. longo in fauces cylindricas ca. 4 mm. longas leviter expanso, dentibus limbi 5 ovato-triangularibus; styli ramis vix clavellatis; achaeniis 5-angularibus stramineo-olivaceis deorsum decrescentibus 3 mm. longis in faciebus et praesertim in costis hirtellis; pappi setis 27–34 substramineo-albidis et saepissime purpureo-tinctis valde inaequalibus sursum scabridulis.— MEXICO: on summit of Sierra de Parras, Coahuila, October, 1910, alt. 2745–3050 m., *Dr. C. A. Purpus*, no. 4655 (TYPE Gr., authenticated duplicate Calif.).

E. (§ **Eximbricata**) **glyptophlebium**, spec. nov., fruticosum; ramis teretibus flexuosis striatulis fulvo-tomentellis; internodiis 5–7 cm. longis; foliis oppositis petiolatis oblanceolato-oblongis grosse crenato- vel serrato-dentatis basi (quarta parte longitudinis) integerrimis paullulo angustatis imam ad basin rotundatis vel subcuneatis 1.5 dm. longis 5 cm. latis coriaceis penniveniis utrinque viridibus et reticulatis in costa venisque principibus pilosulis aliter glabris, venulis subtus (sub lente) sulcatis; petiolo 1.5 cm. longo; corymbis terminalibus compositis usque ad 12–14 cm. diametro convexis multicapitulatis fulvo-tomentellis; capitulis pedicellatis ca. 14-floris 10–11 mm. altis; involucri subcylindrici 5 mm. alti squamis 10–12 anguste oblongis subaequalibus molliter pilosis; corollis ut videtur albis vel roseis

5 mm. longis glabris, tubo proprio 2 mm. longo gradatim in fauces 3 mm. longas ampliato, dentibus limbi 5 lanceolatis patentibus; achaeniis 3.8–5 mm. longis atrobrunneis in costis cum granulis sparsis scabratis in faciebus glabris; pappi setis ca. 28 roseis 5.5 mm. longis.— COLOMBIA: hillside near Tequendama, alt. 2500–2700 m., *Pennell,* no. 2641 (TYPE Gr.).

E. (§ **Eximbricata**) **hammatocladum** Britton & Robinson, spec. nov., fruticosum 2–3 m. altum; ramis teretibus flexuosis foliosis fusco- vel fulvo-tomentellis post foliorum delapsum cum cicatricibus majusculis prominentibus conspicue nodosis; internodiis 1–2 cm. longis; foliis oppositis vel ternis vel quaternis petiolatis obovatis obtusis supra mediam partem repando-dentatis basi integerrimis rotundatis supra laete viridibus minute sparseque punctatis glabriusculis subtus paullo pallidioribus densius punctatis in costa venisque plus minusve fulvo-tomentellis 4–6.5 cm. longis 3–4.5 cm. latis coriaceis penniveniis; petiolo 1 cm. longo; corymbis terminalibus compositis planiusculis fulvo-tomentellis; capitulis ca. 7-floris pedicellatis ca. 7 mm. altis; involucri campanulati squamis ca. 9, interioribus subaequalibus oblongis apice rotundatis ciliolatis 1–3-nerviis, 1–3 extimis brevioribus lanceolatis dorso puberulis; corollis albidis 4 mm. longis sparse papillosis, tubo proprio 1.5 mm. longo gradatim in fauces 2.5 mm. longas paullo ampliato; achaeniis 2.5 mm. longis cum granulis in faciebus sparse asperatis; pappi setis ca. 21 lutescenti-albidis firmiusculi-capillaribus ca. 4 mm. longis.— JAMAICA: Peckham Woods, Upper Clarendon, alt. 762 m., 28 December, 1917, *William Harris,* no. 12,795 (TYPE Gr., N. Y.).

An attractive and clear-cut species with bright-green thickish repand-dentate leaves in texture, contour, and toothing recalling those of *Hamamelis.*

E. (§ **Eximbricata**) **hylibates,** spec. nov., fruticosum 1.2–2.4 m. altum; caule robusto tereti medulloso fulvo-tomentoso (pilis crispis cum glandulis sessilibus globosis numerosis intermixtis); foliis oppositis longe petiolatis oblongo-ovatis acutiusculis vel breviter acuminatis basi rotundatis vel leviter cordatis margine crenato-serratis (crenaturis ca. 1 mm. altis et 4 mm. latis) supra viridibus et in costa et venis principibus paullo fulvido-puberulis subtus multo pallidioribus et crispe fulvo-pubescentibus penniveniis 1.1–1.8 dm. longis 7–12 cm. latis; petiolo robusto fulvo-tomentello subtereti 5 cm. vel ultra longo; corymbo composito trichotomo multicapitulato leviter convexo denso 1.5–2 dm. diametro foliaceo-bracteato; capitulis ca. 7 mm. altis ca. 14-floris; involucri squamis ca. 12 lanceolato-linearibus acutiusculis subaequalibus (1–2 extimis brevioribus exceptis) ca. 4.5–5 mm. longis vix nervatis dorso paullo granulatis; corollis albis 4.7 mm. longis; tubo proprio gracili 2 mm. longo cum glandulis paucis globosis sessilibus instructis; faucibus campanulato-cylindricis 2.7 mm. longis glabris; dentibus limbi 5 recurvatis; styli ramis subfiliformibus; achaeniis brunneo-nigrescentibus in faciebus glabris in costis (pallidioribus) paullo hispidulis apice cum annulo flavidulo pappifero coronatis et cum nectario cupuliforme crenatulo instructis; pappi setis ca. 25 flavido-albis paullo scabridis.— COLOMBIA: in open places in the border of the forest, Rio Frio, Dept. Magdalena, alt. 2300–2750 m., *Kalbreyer*, no. 1956 (TYPE K., phot. Gr.).

E. (§ **Eximbricata**) **intercostulatum**, spec. nov., fruticosum puberulum; ramis teretibus post exsiccationem angulato-costatum adscendentibus; foliis oppositis petiolatis deltoideis acutis basi subtruncatis sed ad insertionem breviter acuminatis, ima e basi 3-nerviis, crenato-dentatis basi integerrima excepta, membranaceis parce granulari-puberulis subtus paullo pallidioribus 3–3.5 cm. longis subaequilatis, dentibus 1.5–2 mm. altis 3–4 mm. latis; corymbis parvis densiusculis multicapitulatis terminalibus et ex axillis superioribus oriuntibus; capitulis ca. 15-floris 6.5 mm. altis 6 mm. diametro; involucri campanulati squamis ca. 13 plerisque subaequalibus lanceolatis attenuatis ca. 3 mm. longis dorso griseo-puberulis; corollis albis 3.5 mm. longis glabris, tubo proprio faucibus subcylindricis bis breviore; styli ramis filiformibus; achaeniis sub-10-costulatis (costulis secundariis 5 vel saltim 3–4 inter primarias singulatim distributis, omnibus sursum hispidulis) 2.3 mm. longis; pappi setis ca. 40 albidis sursum sub lente scabratis ca. 2.5 mm. longis.— COLOMBIA: Truandó, in the northern part of the Intendencia del Chocó, February, 1858, *Dr. Arthur Schott*, no. 3 (TYPE Field Mus., phot. Gr.).

In the secondary ribs of the achenes this species recalls the case of *Brickellia Fendleri* Gray, for a discussion of which see Robinson, Mem. Gray Herb. i. 12 (1917). Here also, as in that case, the chief technical distinction between *Eupatorium* and *Brickellia* breaks down and it becomes necessary to infer the affinities of the species concerned from habit and traits of minor weight. In the present case it appears to the writer that there can be no doubt that the plant is a true *Eupatorium*, although somewhat anomalous in its achenes.

E. (§ **Cylindrocepala**) **iridolepis**, spec. nov., fruticosum 12–15 dm. altum; caule tereti purpureo-brunneo crispe griseo-tomentello flexuoso; internodiis 3–6 cm. longis; foliis oppositis ovatis petiolatis in axillis proliferis longe acuminatis basi breviter rotundato-cuneatis

6–7 cm. longis 2.4–3 cm. latis basi apiceque exceptis crenato-serratis (dentibus 4–7 mm. latis vix usque ad 1 mm. altis) supra basin 3-nerviis supra minute hirtellis subtus in nervis venisque molliter pubescentibus crebre aureo-punctatis; corymbis terminalibus densiusculis convexis multicapitulatis ca. 1 dm. diametro; capitulis ca. 10-floris 9.5 mm. longis 3–4 mm. crassis sessilibus ad apices ramulorum ternis et quaternis fasciculatis; involucri gracile cylindrici 7 mm. alti squamis ca. 18 ca. 4–5-seriatim imbricatis plerisque anguste oblongis basi laete albis glabris apicem versus breviter subherbaceis viridibus vel (intimis) pulchriter roseo-purpureis, apice subherbaceo squamarum intermediarum plus minusve squarroso subpatente acutiusculo tomentello; corollis ut videtur roseis 4.5 mm. longis, tubo proprio 1 mm. longo, faucibus vix distinctis sensim sursum ampliatis extus 5-nerviis inter nervos cum glandulis stipitatis paucis munitis; achaeniis gracilibus 3.3 mm. longis in costis et in faciebus breviter hispidulis; nectario conspicuo depresso; pappi setis ca. 28 capillaribus laete albis 4 mm. longis.— COLOMBIA: open hillside, edge of forest, Las Nubes near Santa Marta, alt. 1370 m., December, *H. H. Smith*, no. 615 (TYPE Gr.).

A highly attractive species distributed under the name of *Eupatorium pulchellum* HBK., a Mexican plant with alternate shorter-petioled leaves and obtuse unappendaged involucral scales. The name *iridolepis* alludes to the parti-colored involucral scales which under low magnification have unusual beauty of form and color.

E. (§ **Eximbricata**) **Jahnii**, spec. nov., fruticosum; caulibus (vel ramis) teretibus 5 mm. diametro purpureo-brunneis juventate viscidulis molliter villosis maturitate glabratis plus minusve vernicosis; internodiis ca. 3 cm. longis; foliis oppositis breviter petiolatis oblongis coriaceis acutis vel saltim acutiusculis margine (basi cuneata excepta) serrato-dentatis (dentibus 0.5–0.8 mm. altis 4–5 mm. latis) penniveniis (venis ca. 10-jugis) supra subglabris (costa et venis juventate paullo villoso-lanulatis) subtus in costa venisque sordido- vel fulvo-villosis vel -lanatis 6–9.5 cm. longis 2.3–4 cm. latis; petiolo ca. 8 mm. longo supra sulcato basi paullo dilatato; corymbo terminali sessili composito trichotomo multicapitulato planiusculo vel leviter convexo 8–10 cm. diametro; capitulis 6-floris ca. 11 mm. altis 4 mm. diametro; involucri anguste campanulati squamis ca. 11 lanceolatis inaequalibus laxe (ca. 2-seriatim) imbricatis viscidis ciliatis; corollis 6 mm. longis glabris; tubo proprio ca. 1.8 mm. longo; faucibus ca. 4.2 mm. longis gradatim leviterque sursum dilatatis; dentibus limbi 5 lanceolato-deltoideis recurvatis; antheris apice cum appendice longiuscula oblonga instructis; achaeniis 3.5 mm. longis in costis sursum hispidulis; pappi setis ca. 37 flavidulo-albidis plerisque ca. 6 mm. longis (paucis multo brevioribus).— VENEZUELA: Sierra de Nevada de Mérida, Rio Nuestro Señora, alt. 3000–4000 m., *Dr. Alfredo Jahn*, no. 80 (TYPE U. S., phot. Gr.).

E. (§ **Conoclinium**) **lanulatum**, spec. nov., herbaceum vel paullulo lignescens decumbens 3–4 dm. altum; radice fibrosa quasi annua; caulibus 1–3 teretibus foliosis paullo flexuosis griseo-lanulatis; foliis oppositis breviter petiolatis lanceolatis crenulatis apicem versus gradatim angustatis (sed apice vero obtuso vel rotundato) supra viridibus vix cum vestigiis indumenti arachnoidei-puberuli tectis subtus albido-lanulatis penniveniis basi integris cuneatis 1–1.5(–3) cm. longis 2–4(–10) mm. latis; crenaturis utroque ca. 7; venis utroque ca. 9; petiolo 3–4 mm. longo; corymbis parvis terminalibus densiusculis 12–20-capitulatis 2–6 cm. diametro plerumque longe pedunculatis; capitulis ca. 20-floris ca. 7 mm. altis; involucri campanulati squamis 12–14 lanceolatis subtriseriatim imbricatis firmiusculis peracutis pilosulis vel glabrescentibus viridibus plerumque 3-nerviis 2–4-costulatis apicem versus purpurascentibus; corollis purpureis 4 mm. longis limbum versus granulari-pilosiusculis aliter glabris; tubo proprio 1.2 mm. longo tenui; faucibus anguste obconicis 2.2 mm. longis; achaeniis brunneo-fuscis 1.7 mm. longis glaberrimis basi calcaratis; pappi setis ca. 30 basi in annulum angustissimum connatis.— COLOMBIA: Guadalupe near Bogotá, alt. 2000 m., *Bros. Apollinaire & Arthur*, no. 33 (TYPE U. S., phot. Gr.); without precise locality, *Triana*, no. 1169 (K.).

This species clearly belongs to the small group of Colombian Eupatoriums of § *Conoclinium* of which *E. microphyllum* L. f. is probably the best known and most characteristic species. It differs from *E. microphyllum* in being a somewhat larger plant with lanceolate leaves cuneate at the base instead of roundish-ovate and cordate. The indument of the stem is also quite different being a very fine subappressed woolliness, while in *E. microphyllum*, at least on the peduncle, the hairs tend to spread widely and are somewhat stiffer in character.

E. (§ **Subimbricata**) **macrophylloides**, spec. nov., fruticosum elatum 3–4 m. altum; ramis teretibus costato-subangulatis dense fulvescenteque lanatis molliter lignescentibus medullosis; internodiis 3–8 cm. longis; foliis oppositis longe petiolatis deltoideo-ovatis 1 dm. longis 8 cm. latis acutis vel acuminatis basi subtruncatis ad insertionem brevissime cordatis usque ad basin crenulatis (dentibus numerosis 0.5–0.8 mm. altis 1–2 mm. latis) a basi 3-nerviis (nervis lateralibus extrorsum fere ab incepto denuo ramosis) supra pulverulo-puberulis subtus multo pallidioribus griseis molliter tomentellis et atomiferis; petiolo usque ad 6 dm. longo; corymbis compositis trichotomis, partialibus convexis 6–10 cm. diametro densis multicapitulatis; capitulis breviter pedicellatis ca. 11-floris 7 mm. altis 3.2–3.5 mm. diametro; involucri subcylindrici squamis ca. 18 valde inaequalibus ca. 4-seriatim laxius imbricatis tenuibus stramineis, interioribus oblongo-linearibus apice rotundatis, exterioribus gradatim brevioribus obtusis ciliolatis, extimis ovatis acutiusculis dorso villosulis; receptaculo minimo planiusculo glabro; corollis ut videtur albidis 4 mm. longis, tubo proprio gracili fauces sensim paullo ampliatas subaequante, dentibus limbi 5 recurvatis; styli ramis filiformibus; achaeniis 2 mm. longis in faciebus et in angulis hispidulis; pappi setis albis capillaribus ca. 36 inaequalibus, aliis ca. 3.5 mm. longis, aliis quartem vel tertiam partem brevioribus.— VENEZUELA: at Sanchorquig (a name written with fair clearness upon the original label but not found on any available map), *Eggers*, no. 13,413 (TYPE U. S., phot. Gr.).

Although this species in foliage and general form of the inflorescence slightly suggests *E. macrophyllum* L., it differs in many important details (fewer florets, cylindrical rather than campanulate involucre, glabrous receptacle, etc.) and is clearly of § *Subimbricata.* Although cylindrical in form the involucre does not have the texture or close imbrication which characterize § *Cylindrocephala.*

E. (§ **Subimbricata**) **magdalenense,** spec. nov., perenne herbaceum erectum vel inclinatum 3–9 dm. altum; ramis brunneis obscure hexagonis mox glabratis laevissimis; ramulis inflorescentiae aliquid cum pilis minutis incurvis instructis; foliis oppositis (vel rameis alternis) anguste ovatis attenuato-acuminatis basi rotundatis argute serratis crassiuscule membranaceis paullulo succulentis utrinque viridibus et glabris 4–4.5 cm. longis 2–2.5 cm. latis a basi 3(–7)-costatis; venulis reticulatis translucentibus; petiolo 8–14 mm. longo; ramis primariis inflorescentiae late patentibus curvato-adscendentibus cum ramulis 3–7 brevibus subaequalibus (1–3 cm. longis) instructis; his 2–3-foliatis apicem versus floriferis 5–20-capitulatis; capitulis ca. 25-floris 6.5 mm. altis 5 mm. diametro; involucri campanulati 5 mm. alti et crassi squamis lanceolatis acutis minute ciliolatis ca. 3-seriatis subherbaceis persistentibus et denique brunnescentibus; corollis albis 4 mm. longis, tubo proprio ca. 7 mm. longo gradatim in fauces cylindricas ampliato; achaeniis 1.7 mm. longis nigris minute in costis pallidioribus hispidulis.— COLOMBIA: common on open ridges, Sierra del Libano, alt. 1680–1980 m., near Santa Marta, *H. H. Smith,* no. 1993 (TYPE Gr.).

A species in many characters near *E. pycnocephalum*, but quite different in its inflorescence.

E. (§ **Subimbricata**) **Maxonii,** spec. nov., frutescens molliter lignescens 3–4 m. altum; caule tereti fistuloso fulvide puberulo ramoso; ramis oppositis modice patentibus; foliis oppositis ovato-suborbicularibus tenuiter membranaceis utrinque viridibus apice breviter acuminatis basi subtruncatis vel brevissime acuminatis simplice vel plus minusve duplice dentatis lateraliter saepe uni-lobatis vel -angulatis basi pinnatinerviis supra basin trinervatis delicatule reticulatis 10–12 cm. longis 8–10 cm. latis; petiolis 3–5 cm. longis sordide puberulis supra planis vel leviter canaliculatis; capitulis ca. 26-floris sublaxe corymboso-paniculatis graciliter pedicellatis 1 cm. longis; involucri anguste campanulati squamis ca. 23 valde inaequalibus dorsaliter minutissime puberulis 3–6-nerviis, exterioribus ovato-lanceolatis acutis brevioribus (extimis 1–3 lineari-lanceolatis subpatentibus), mediis lanceolatis, interioribus anguste oblongo-lanceolatis acutis, intimis linearibus subacutis apicem versus ciliolatis; corollis graciliter tubulosis 7 mm. longis apicem versus patenter hispidulis aliter glabris verisimiliter albis, faucibus brevissimis obscuris, limbi dentibus 5 breviter deltoideis patentibus vel recurvatis; antheris subliberis apice longiuscule appendiculatis basi subsagittatis; achaeniis glabris nigris lucidis 5-costulato-angulatis 1.5 mm. longis basi callosis et concavis; pappi setis ca. 40 laete albis delicatule capillaribus plerisque subaequalibus (2 vel 3 brevioribus) minute scabratis basi in cupulam connatis; styli ramis longissimis filiformibus.— PANAMA: in humid forests in the vicinity of El Boquete, Chiriqui, alt. 1000–1300 m., 2–8 March, 1911, *William R. Maxon*, no. 4942 (TYPE U. S., dupl. Gr.).

From *E. conspicuum* Kunth & Bouché, a species somewhat similar in its long-petioled, thin, and broadly ovate leaves, *E. Maxonii* differs much in its involucre which is clearly that of § *Subimbricata*. From *E. hylobium* Robinson it differs in the more spreading dentation of the leaves, its longer corollas (7 mm. instead of 4.5 mm.), and considerably more numerous florets and pappus-bristles, as well as its slightly firmer and more acute scales. In *E. oresbium* Robinson, another species of somewhat similar foliage and habit, the heads are smaller and less numerously flowered and the corolla has a more enlarged throat. *E. perornatum* Klatt of Vera Cruz, likewise somewhat similar in habit, has the receptacle hairy and the achenes somewhat hispid, while *E. prionophyllum* Robinson of Costa Rica, which is arboreous, has more ovate, more gradually acuminate leaves, and glabrous corollas about 4.5 mm. long.

E. (§ **Cylindrocephala**) **meridense,** spec. nov., perenne herbaceum vel fruticosum erectum; caule teretiusculo paullulo costato-angulato dense breviterque fulvo-lanato; foliis oppositis lanceolatis utroque attenuato-acuminatis crenulatis vel subintegris 4–6 cm. longis 1–1.5 cm. latis basi in petiolum breve cuneato-alatum gradatim angustatis supra bullatis scabridis puberulis subtus 3-nerviis conspicue exserto-venosis et reticulatis in venis venulisque sordido- vel fulvo-tomentosis; corymbis terminalibus compositis valde rotundatis 1 dm. diametro multicapitulatis; capitulis pedicellatis ca. 10-floris ca. 9 mm. altis ca. 3.5 mm. diametro; involucri cylindrici 4–5-seriatim imbricati squamis ca. 22 regulariter gradatis obscure ciliolatis apice rotundatis vel subtruncatis apicem versus brunnescentibus; corollis graciliter tubulosis verisimiliter purpurascentibus; achaeniis gracillimis 3.2 mm. longis (vix maturis) in costis cum pilis brevissimis subsphaericis ornatis; pappi setis ca. 30 sordide albidis vix scabratis corollam subaequantibus.— *E. scabrum* Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xxviii. 569 (1901), not L. f.— VENEZUELA: at Mérida, *Moritz,* no. 1365 (TYPE Gr.).

This species differs from *E. scabrum* L. f. in having smaller heads, considerably narrower subentire or finely crenulate leaves much more attenuate at each end. The pubescence is also very different, that of the stem being a close matted wool of tawny color instead of the long spreading articulated hairs composing the much harsher and more scattered indument of *E. scabrum.*

E. (§ **Subimbricata**) **microdon,** spec. nov., fruticosum; ramis teretibus curvatis nodosis griseis laevibus; ramulis obscure strigilloso-puberulis; foliis oppositis petiolatis lanceolato-oblongis longiuscule acuminatis basi acutis in margine subrevoluto remote obscureque cuspidato-denticulatis penninerviis (nervis lateralibus ca. 10-jugis prorsus curvatis) utrinque glaberrimis delicatule prominulenter reticulatis subcoriaceis 9–13 cm. longis 2.5–4.8 cm. latis; petiolis 1–1.5 cm. longis; paniculis terminalibus hemisphaericis 6–10 cm. diametro; bracteis parvis anguste oblanceolatis; capitulis in glomerulos sphaericos ca. 5-capitulatos dispositis sessilibus ca. 3-floris 8 mm. longis; involucri subcylindrici squamis valde inaequalibus ca. 9, exterioribus lanceolato-ovatis acutiusculis vel obtusis dorso brevissime pilosulis brevibus persistentibus, intermediis et interioribus *gradatim longioribus minute eroso-ciliolatis* aliter glabrescentibus substramineis caducis; corollis graciliter tubulosis 4.8 mm. longis sine faucibus ullis distinctis, dentibus limbi ovato-deltoideis patentibus subacutis; achaeniis atro-olivaceis 2 mm. longis 5-angulatis glaberrimis; pappi setis 41–50 minute subscabratis corollam subaequantibus; styli ramis clavellatis.— GUATEMALA: in tall woods, Coban, Alta Vera Paz, alt. 1550 m., April, 1908, *H. von Türckheim*, no. II, 2261 (TYPE Gr.).

This species with many of the characters of *E. daleoides* (DC.) Hemsley differs markedly in having its leaves finely and remotely cuspidate-denticulate instead of serrate and very obscurely, if at all, punctate, and in the distinct though fine reticulation on their upper surface.

E. (§ **Subimbricata**) **miserum,** spec. nov., herbaceum gracillimum perenne 2–2.5 dm. altum; radice e fibris duris gracilibus composita; caulibus 1–3 teretibus ca. 1 mm. diametro obscure fulvo-tomentellis simplicibus usque ad inflorescentiam paniculatim ramosam; foliis oppositis lanceolatis attenuatis ad apicem obtusiusculum crenatis (basi anguste cuneata integerrima excepta) membranaceis utrinque viridibus et paullo puberulis a basi 3-nerviis 1–2 cm. longis 2–5 mm. latis; petiolo 2–3 mm. longo; paniculae diffusae ramis inferioribus oppositis superioribus plerumque alternis gracilibus; pedicellis filiformibus 1–9 mm. longis; capitulis 4.5 mm. altis ca. 25-floris 3.5 mm. diametro; involucri turbinato-campanulati persistentis squamis lanceolatis vel lanceolato-linearibus tenuibus viridibus, interioribus subaequalibus glabris, exterioribus paucis gradatis plus minusve dorso puberulis; receptaculo parvo plano calvo glabro; corollis lilaceis vel roseis 2 mm. longis, tubo proprio 5 mm. longo, faucibus subcylindricis distincte ampliatis 1.3 mm. longis, limbi dentibus 5 deltoideis dorso paullulo hispidulis; achaeniis immaturis saltim in angulis pubescentibus.— COLOMBIA: at the Falls of the Truandó, just south of the border of Panama, *Dr. Arthur Schott*, nos. 2 (TYPE Field Mus., phot. Gr.), 1 (Field Mus., phot. Gr.).

An inconspicuous plant clearly of a small group of annuals and slender perennials, represented by *E. sideritidis* Benth., *E. Sinclairi* Benth., *E. capillipes* Benth., and *E. lloense* Hieron.

EUPATORIUM MUELLERI Sch. Bip. ex Klatt, Leopoldina, xx. 90 (1884), as *Mülleri*. Although this name has in recent years been rather frequently employed in identifications of Mexican specimens, it now becomes clear that it has not been rightly applied. Fragments and an excellent sketch of the type of *E. Muelleri* which came to the Gray Herbarium with the Klatt *Compositae* prove it to have been precisely the plant later described and well figured by Coulter, Bot. Gaz. xx. 47, t. 5 (1895), as his proposed monotypic genus *Mallinoa corymbosa*. The writer, Proc. Am. Acad. xlix. 433 (1913), has already

discussed the generic position of *Mallinoa* and shown that it is of the genus *Eupatorium*, where it approaches very closely the species *E. bellidifolium* Benth. At that time it seemed unwise to rename *Mallinoa corymbosa* under *Eupatorium*, from a suspicion that the plant might already have been somewhere so treated, which now proves to have been the case. Klatt misleadingly described the species as shrubby. This is certainly not the case. It is an herbaceous perennial, leafy chiefly at or near the base and with consequent subscapose habit. The more leafy plant, long passing in herbaria as *E. Muelleri*, is described above as *E. choricephalum* and may be readily separated by its broadly ovate distinctly cordate leaves, distributed well into the open inflorescence, as well as by many other characters.

E. (§ **Subimbricata**) **ornithophorum**, spec. nov., herbaceum perenne griseo-viride tomentellum; caule striato-angulato griseo-brunneo, internodiis 6–12 cm. longis; foliis lanceolatis caudato-acuminatis penniveniis obtuse et irregulariter dentatis supra bullatis et scabridis subtus multo pallidioribus griseo-tomentosis 1 dm. longis 2.5–3.5 cm. latis basin versus primo paullo contractis deinde in discum suborbiculare dentatum perfoliatum ca. 2.4–4 cm. diametro dilatatis; foliis supremis bracteiformibus multo reductis angustatis attenuatatis subintegris; panicula griseo-tomentella ca. 2 dm. alta et crassa; ramulis late patentibus, lateralibus terminales saepius longe superantibus; capitulis ca. 22-floris 7 mm. altis 4 mm. diametro subsessilibus glomeratis; involucri campanulati ca. 4-seriati griseo-tomentelli squamis lanceolatis vel intimis linearibus acutis; receptaculo plano calvo glabro; corollis 3 mm. longis purpureis vel violaceis tubulatis a basi ad apicem paullulo dilatatis sed sine faucibus distinctis; styli rami filiformibus elongatis papillosis attenuatis non glabratis; achaeniis 1.2 mm. longis in faciebus granulatis.— COLOMBIA: in the Cordillera Oriental east of Neiva, August 7, 1917, *Rusby & Pennell*, no. 1034 (TYPE N. Y., fragm. and phot. Gr.); foot of Cordillera, near Neiva, *Rusby & Pennell*, no. 479 (N. Y., fragm. Gr.).

E. (§ **Subimbricata**) **Pennellii**, spec. nov., herbaceum erectum 10–14 dm. altum exsiccatione fuscescens; caule tereti atropurpureo maturitate glabrato laevissimo sed obscuro infra simplici supra paniculatim ramoso; foliis oppositis petiolatis ovatis caudato-attenuatis basi rotundatis argute serratis (dentibus 14–18 utroque latere 0.7 mm. altis 1.5–2.5 mm. latis) membranaceis plerisque a basi 5-nervatis ca. 5 cm. longis 3.5 cm. latis supra in nervis sparse pubentibus infra subglabris; petiolo 1–1.5 cm. longo; panicula elongata ovoidea ca. 5 dm. longa 2 dm. diametro; ramis oppositis divaricatis saepe flexuosis

puberulis, pilis incurvis; cymis ca. 4–7-capitulatis 2–3 cm. diametro convexis laxiusculis, pedicellis 3–6 mm. longis; capitulis 7 mm. altis ca. 25-floris; involucri glabriusculi campanulati squamis stramineo-scariosis 3–4-seriatis plerisque 2-costatis (costis e callo conspicuo basilari oriuntibus), interioribus elliptico-oblongis apice erosis obtusis vel rotundatis, exterioribus gradatim brevioribus ovatis ciliatis dorso paullo pubescentibus; corollis albis 3.5 mm. longis glabris, tubo proprio 1 mm. longo, faucibus vix ampliatis cylindricis 2 mm. longis, limbi dentibus 5 ovato-deltoideis 0.5 mm. longis; achaeniis 2 mm. longis nigrescentibus in costis pallidioribus patenter hispidulis.—COLOMBIA: at the foot of the Cordillera Oriental near Neiva, *Rusby & Pennell*, no. 626 (TYPE Gr., dupl. N. Y.).

E. (§ **Subimbricata**) **perezioides**, spec. nov., gracile perenne erectum 4–5 dm. altum; caule tereti ad inflorescentiam simplici fusco-tomentoso et glandulari, internodiis inferioribus 2–12 mm. longis, superioribus 2–3 cm. longis; foliis oppositis ovato-ellipticis obtusis cordatis crenato-serratis firmis subcoriaceis supra atroviridibus et cum glandulis sessilibus vel breviter stipitatis conspersis infra multo pallidioribus griseo-tomentosis glandularibus 4–7 cm. longis 2.5–4 cm. latis basi ima penniveniis paullo supra basin tamen 3-nervatis venulis utrinque prominulis reticulatis; petiolis 2–3 mm. longis fusco-tomentosis; panicula diffusa 12–30-capitata, ramis oppositis divaricatis longis flexuosis subfiliformibus; pedicellis 1–2.5 cm. longis; capitulis ca. 36-floris ca. 8 mm. altis 5 mm. diametro; involucri campanulati 3–4-seriati squamis purpureo-brunneis ca. 3-nerviis, exterioribus brevibus late ovatis obtusis, interioribus gradatim longioribus angustioribus acutioribus; corollis viridi-albis limbum versus purpureo-tinctis, tubo proprio gracili 2.3 mm. longo, faucibus campanulatis distincte ampliatis 1.2 mm. longis, limbi dentibus 5 breviter deltoideis patentibus vel recurvis; styli ramis filiformibus perlongis; achaeniis 2 mm. longis rubro-brunneis in costis hispidulis; pappi setis 27–36 vix scabratis 3.7 mm. longis.—COLOMBIA: "Buenavista," west of Villavicencio, Dept. Meta, alt. 1000–1200 m., *Pennell*, no. 1678 (TYPE Gr.).

Not very closely related to any hitherto described species, and to be readily recognized by its diffuse inflorescence and *Perezia*-like habit.

E. (§ **Eximbricata**) **rorulentum**, spec. nov., fruticosum vel arboreum fulvo-tomentellum; ramis teretibus; ligno albo duro, cortice fusco brunneo; ramulis adscendentibus subfastigiatis foliosis fulvo-tomentellis teretibus vel obscure hexagonis; foliis oppositis petiolatis late ovatis obtusis serratis (basi leviter cordata integra) 2–2.8 cm. longis 1.5–2 cm. latis coriaceis basin versus penniveniis supra basin 3-nervatis utrinque reticulatis supra dense cum glandulis sessilibus praeditis aliter glabris subtus fulvo-pubescentibus et sparsius glanduliferis; petiolo 1–3 mm. longo fulvo-tomentello; corymbis numerosis parvis in ramis terminalibus; ramulis pedicellisque griseo-hirsutis; capitulis ca. 10-floris ca. 6 mm. altis; involucri campanulati squamis 7–10 subaequalibus vix imbricatis lanceolato-oblongis acutiusculis dorso fulvo- vel griseo-tomentosis; receptaculo parvo plano calvo glabro; corollis (valde immaturis) verisimiliter albidis 5 mm. longis glabris; tubo proprio ca. 1 mm. longo; faucibus distincte ampliatis subcylindricis ca. 3 mm. longis; achaeniis deorsum attenuatis in angulis cum glandulis sessilibus vel brevissime stipitatis praeditis.— COLOMBIA: Guadalupe, Dept. Cundinamarca, alt. 2900 m., *Bros. Apollinaire & Arthur,* no. 27 (TYPE Gr.).

EUPATORIUM ROTHROCKII Gray. This species seems to be capable of subdivision into the following varieties.

Var. **typicum,** foliis firmiuscule membranaceis ovatis vel lanceolatis basi obtusis vel rotundatis serratis (dentibus acutis) laeti- vel flavescenti-viridibus.—*E. Rothrockii* Gray, Syn. Fl. i. pt. 2, 102 (1884). *Kyrstenia Rothrockii* (Gray) Greene, Leafl. i. 9 (1903).— ARIZONA: Mt. Graham, alt. 2745 m., September, 1874, *Dr. J. T. Rothrock,* nos. 740, 741; Pine Cañon, alt. 2440 m., 1 Oct., 1909, *Blumer,* no. 3434. CHIHUAHUA: southwestern part of state, Aug.–Nov. 1885, *Palmer,* no. 375; shaded ledges of the Sierra Madre, 8 Oct. 1887, *Pringle,* no. 1265 (mixed with *E. Lemmoni* Robinson); mountain near Pilares, Strawberry Valley, 22 Sept. 1891, *Hartman,* no. 752; near Colonia Garcia, alt. 2250 m., 12 Sept. 1899, *Townsend & Barber,* no. 325.

Var. **Shrevei,** var. nov., foliis tenuioribus deltoideo-ovatis cordatis vel basi truncatis majoribus usque ad 1 dm. longis et 7 cm. latis grosse crenatis fuscescente viridibus; inflorescentia, involucris, flosculis ut apud var. *typicum.*— ARIZONA: Ramsey Cañon, Huachuca Mountains, alt. 1680 m., 25 Sept. 1916, *Dr. Forrest Shreve,* no. 5017 (TYPE Gr.). Seemingly something more than a mere shade form, although without any as yet detected floral differences.

E. (§ **Subimbricata**) **sciaphilum,** spec. nov., fruticosum vagum 2–4 m. longum molliter lignosum; ramis teretibus glabris purpurascenti-griseis ramulis fulvescenti-puberulis, pilis crispis; foliis oppositis spatulato-obovatis vel -oblanceolatis integerrimis utrinque glabris molliter coriaceis sessilibus vel brevissime petiolatis obtusis basi cuneatis 5–8 cm. longis 1.8–3.2 cm. latis, nervo medio supra impresso subtus prominulo, nervulis lateralibus pinnatis obscurissimis ca. 5-jugis; capitulis ca. 10-floris in corymbum laxum valde convexum 1–1.5 dm. diametro dispositis graciliter pedicillatis; bracteis lineari-subulatis; involucri subcylindrici squamis ca. 9, interioribus linearibus oblanceolatis uninerviis ciliolatis aliter glabris ut videtur purpureis acutis subaequalibus, extimis 2–3 multo brevioribus ovatis acutiusculis medio plus minusve incrassatis; flosculis valde exsertis; corollis glaberrimis graciliter tubulosis 7 mm. longis deorsum decrescentibus sine faucibus distinctis, limbi dentibus ovato-deltoideis suberectis; achaeniis gracilibus 4 mm. longis 5-angulatis basi attenuatis in costis basin et apicem versus paullulo patenter hispidulis; pappi setis ca. 48 albidis capillaribus vix scabratis corollam subaequantibus; styli ramis filiformibus.— COLOMBIA: Dept. Antioquia, alt. 2292–2350 m., in light shade of forest, 25 July, 1880, *Kalbreyer*, no. 1445 (TYPE K.).

This species, communicated to the Kew Herbarium by Messrs. Veitch, Nov. 1880, is said to have glossy foliage and dark purplish-violet handsome flowers. It seems promising for horticulture, but appears never to have received a name or scientific description. In its thick coriaceous foliage and the somewhat calyculate nature of the involucre it shows similarity to the Mexican *E. araliaefolium* Lessing, which, however, has lance-oblong acuminate leaves, more numerously flowered heads, and achenes hispid on the angles from the summit to the base.

E. (§ **Eximbricata**) **sciatraphes**, spec. nov., fruticosum primo aspectu laevissimum sed inflorescentia puberulum (pilis minutis attenuatis curvatis articulatis purpurascentibus); caule subtereti costulato juventate purpureo-brunneo maturitate griseo; internodiis 2–5 cm. longis; foliis oppositis petiolatis ovatis acuminatis apicem versus integris saepe falcatis lateraliter grosse crenatis (crenaturis ca. 2 mm. altis ca. 8 mm. latis) basi obtusis vel rotundatis subcoriaceis vel chartaceis supra in costa paullo puberulis aliter glaberrimis lucidulis viridibus subtus glaberrimis paullo pallidioribus 7–9 cm. longis 3–4 cm. latis supra basin 3-nervatis; nervis inter se a venis transversis connexis; corymbo terminali amplo leviter convexo laxiuscule ramoso ca. 18 cm. diametro basi foliaceo-bracteato supra bracteolis minimis integris spatulatis instructo; pedicellis rectis subfastigiatis apice plerisque capitula 2 vel 3 sessilia gerentibus; capitulis 8–13-floris ca. 6.5 mm. altis; involucri turbinato-campanulati squamis 10–12 lanceolatis vix imbricatis modice inaequalibus subacutis dorso paullo granulatis; corollis subcylindricis 2.5 mm. longis sensim dilatatis in tubo extus sparse papillosis aliter laevibus; achaeniis deorsum decrescentibus 2 mm. longis in costis paullo hispidulis apice cum nectario purpurascenti breviter cylindrico instructis; pappi setis flavidulo-albidis vix scabratis.— SANTO DOMINGO: shady places at Altamira, alt. 420 m., *Eggers*, no. 2423 (TYPE N. Y., fragm. Gr.).

E. (§ **Subimbricata**) **Squiresii** Rusby, spec. nov., perenne elatum herbaceum vel verisimiliter fruticosum; caule tereti viridi glabro laevissimo medulloso; foliis oppositis breviter petiolatis oblongis acuminatis (apice vero saepe obtusiusculo) basi angustatis deinde *rotundatis vel paullulo in petiolum decurrentibus penniveniis (venis* utroque ca. 10 prorsus curvatis inter sese anastomosantibus) repando-dentatis membranaceis utrinque viridibus glabris vel praecipue subtus in costa venisque sordide puberulis 9–22 cm. longis 4.5–10 cm. latis; panicula terminali ampla ad 3 dm. longa 1–2 dm. diametro laxa patenter ramosa inferne folioso-bracteata, ramis denuo ramosis puberulis apicem versus cymoso-furcatis; capitulis breviter pedicellatis glomerulatis ca. 6 mm. altis ca. 3.5 mm. diametro ca. 22-floris; involucri campanulato-subcylindrici squamis ca. 21 tenuibus stramineis valde inaequalibus 3–4-seriatim imbricatis regulariter gradatis apice rotundatis et dorso villosulis 1–3-nerviis 2–4-costulatis; corollis flavescente albidis 3.5 mm. longis ad limbum extus granulosis aliter glabris; styli ramis filiformibus papillosis; achaeniis nigris 1.3 mm. longis hispidulis; pappi setis ca. 30 capillaribus 3 mm. longis laete albis.— VENEZUELA: at Paloma, Delta Amacuro (in the region of the lower Orinoco), April, 1896, *Rusby & Squires*, no. 2 (TYPE N. Y., dupl. Gr., Mo., etc.).

Described by permission of Dr. H. H. Rusby, who long ago recognized the novelty of the plant but through pressure of professional duties has been unable to study it in detail and give it published record. The species is dedicated to his associate Mr. Roy W. Squires, who accompanied him on the arduous trip of exploration during which this plant, together with many others, was discovered.

EUPATORIUM TACOTANUM Klatt. This species, secured by several collectors at different points in Colombia, exhibits some variations worthy of note, the nature of which may be stated thus:

Var. **typicum,** involucri squamis plerisque 1-nerviis, extimis exceptis subglabris, intermediis lanceolato-linearibus acutiusculis, intimis linearibus acutis apice purpureis.— *E. tacotanum* Klatt in Engl. Bot. Jahrb. viii. 35 (1887).— A variety exhibiting two forms:

Forma **normale,** capitulis, ut dixit cl. Klatt, l. c., longe pedicellatis; pedicellis 3–10 mm. longitudine.— COLOMBIA: in bushy places of the savannahs around Tocotá, alt. 1600 m., *Lehmann*, n. 3424 (TYPE Gr.).

Forma **apodum**, forma nov., capitulis plerisque sessilibus in glomerulos 2–4-capitulatos dispositis; pedicellis paucissimis usque ad 2.8 mm. longis evolutis.— Same locality, habitat, and altitude, *Lehmann*, n. 3438 (TYPE Gr.).

Var. **trineurolepis**, var. nov., ut dicitur herbaceum 6 dm. altum habitu, inflorescentia, pubescentia, etc. vere in partibus omnibus involucro excepto ut apud var. *typicum* sed differt involucri squamis distincte 3-nerviis paullo magis oblongis obtusis vel apice rotundatis extus apicem versus tomentellis.— COLOMBIA: Papagayeros, Dept. El Valle, in clayey soil, alt. 800 m., 3 Nov. 1899, *E. Langlassé*, no. 9 (TYPE Gr.). The differences in the scales, which in the typical variety are as to the intermediate ones lance-linear, acutish, and 1-nerved, while here they are oblong-linear, obtusish, more copiously pubescent, and 3-nerved, are striking and might possibly justify separate specific rank. However, the plants appear to be otherwise identical throughout, and some slight variation has been observed in the scales of the typical variety of which several collections are now at hand, some of the intermediate scales being occasionally 3-nerved. It is therefore probable that a more extended series will bridge the gap between the two varieties. It may be remarked that, although Klatt, following a manuscript note of Lehmann, described his plant as a shrub reaching 3 m. in height and Langlassé notes his plant as an herb 60 cm. in height, the specimens themselves (showing in each case about 2.5–3 dm. of stem) exhibit no significant difference in the degree of lignescence, which if any distinction can be made is more pronounced in Langlassé's plant.

E. (§ **Subimbricata**) **tovarense**, spec. nov., herbaceum et perenne vel fortasse fruticosum (basi ignota); caulibus vel ramis teretibus gracilibus virgatis 2 mm. diametro sordide puberulis; foliis oppositis petiolatis lanceolato-oblongis attenuato-acuminatis basi cuneatis penniveniis 7–11 cm. longis 2.8–3.3 cm. latis primo aspectu integris sed remote obscureque cuspidato-denticulatis membranaceis utrinque viridibus supra glabris subtus puncticulatis atomiferis in costa venisque puberulis; venis utroque ca. 6 prorsus curvatis et inter sese anastomosantibus; petiolo ca. 1 cm. longo; paniculis terminalibus oppositirameis foliaceo-bracteatis 1–3 dm. longis 1–2 dm. diametro, ramis divaricatis basin versus nudis; ramulis brevibus etiam divaricatis; pedicellis plerisque 1–3 mm. longis; capitulis ca. 13-floris ca. 6 mm. altis 3.5 mm. diametro; involucri campanulati squamis ca. 21 stramineo-scariosis apice rotundatis regulariter 3–4-seriatim gradatis dorso praecipue apicem versus puberulis, extimis ovatis brevissimis, ceteris oblongis vel lineari-oblongis plerisque 3-veniis 2–4-costatis; corollis 3 mm. longis in limbo brevissime 5-dentato extus granulosis aliter glabris, tubo proprio fauces vix ampliatas subaequante; achaeniis nigris 1.5 mm. longis in faciebus paullo papillosis in angulis papilloso-hispidulis; pappi setis ca. 36 albis vix scabratis capillaribus 2.4 mm. longis; styli ramis filiformibus papillosis.— VENEZUELA: near Tovar, State of Mérida, alt. 1220 m., *Fendler,* no. 1947 (TYPE Gr.).

E. (§ **Eximbricata**) **Trianae,** spec. nov., herbaceum perenne crispe tomentellum; caulibus teretibus striatis indumento brevissimo brunescente tectis sursum alterni-ramosis foliosis; foliis caulinis alternis lanceolato-linearibus 6–10 cm. longis 5–10 mm. latis remote obscureque denticulatis vel integerrimis utroque attenuatis uninerviis pinnativeniis supra reticulato-rugulosis et puberulis subtus pallidioribus reticulatis sordide griseo-tomentosis, foliis rameis saepissime oppositis minoribus; petiolis vix 2–3 mm. longis tomentosis; capitulis ca. 28-floris subsessilibus in glomerulos globosos subsessiles vel breviter pedunculatos paniculatim dispositos aggregatis 5 mm. altis 5 mm. diametro; involucri squamis ca. 16 anguste oblanceolato-oblongis subaequalibus acutis 3-nerviis ciliatis dorso hirsutulis et cum glandulis numerosis sessilibus globularibus munitis; receptaculo glabro modice convexo; corollis 2.2 mm. longis colore incertis a basi ad apicem gradatim ampliatis 5-nervatis inter nervos apicem versus cum glandulis sessilibus globosis sparsis, dentibus limbi 5 recurvatis; achaeniis 5-costatis 5-angulatis nigris 1.2 mm. longis inter costas cum glandulis paucis instructis; pappi setis 21 sordide albis 1.8 mm. longis sursum minute scabratis; antheris oblongis basi rotundatis apice cum appendice oblongo-deltoidea munitis; styli ramis filiformibus.— COLOMBIA: without precise locality, *Dr. J. Triana,* no. 1196 (TYPE K.).

Unfortunately, no detailed data accompany this interesting plant which, like many others of Dr. Triana's Colombian material, was purchased by the Royal Gardens in February, 1892, but is unaccompanied by any original ticket. The species is exceedingly distinct from any other *Eupatorium* known to the writer, yet there can be little doubt that it is correctly referred to the genus.

E. (§ **Cylindrocephala**) **uromeres,** spec. nov., fruticosum gracile 12 dm. altum; caule tereti tomentello glabrescente flexuoso verisimiliter scandente ramoso; ramis longis patentibus saepe patenter dichotomis; foliis oppositis petiolatis 4–6 cm. longis 2–3 cm. latis ovatis acutis basi rotundatis deinde brevissime cuneatis membranaceis supra minute papillosis subtus reticulatis molliter tomentellis a basi trinerviis obscure remoteque serratis dentibus 5–6 mm. latis vix 0.5 mm. altis; petiolo gracili tomentello 5–8 mm. longo; cymis axillaribus oppositis plerisque 3–5-capitulatis; pedicellis lateralibus late patentibus subfiliformibus canescenti-tomentellis; capitulis campanulato-cylindricis ca. 45-floris 7 mm. altis 4 mm. diametro; involucri squamis ca. 50 albis uninerviis ca. 5-seriatim imbricatis apice cum appendice subulata herbacea patente vel deflexa ca. 0.7 mm. longa munitis; corollis 3 mm. longis purpurascentibus, tubo proprio 1.7 mm. longo sparse papilloso sursum in fauces 1 mm. longas paullo ampliato dentibus limbi 5 anguste ovatis 0.3 mm. longis; achaeniis 2.8 mm. longis gracilibus 5-costatis faciebus nigris glabris lucidulis, costis stramineis eroso-serratulis; pappi setis ca. 28 albis breviter hispidulo-scabratis 3 mm. longis.— COLOMBIA: occasional in thickets and dry forests below 915 m., fl. May–Dec., near Santa Marta, expedition of 1898–'99, *H. H. Smith*, no. 505 (TYPE Gr.).

A species readily distinguished by its caudate involucral scales.

E. (§ **Cylindrocephala**) **xestolepis**, spec. nov., ut videtur fruticosum (basi ignota); caulibus teretibus 3–4 mm. diametro lanatis maturitate glabrescentibus fuscescentibus medullosis; ramis divaricatis curvatis sordide lanato-villosissimis; foliis oppositis petiolatis ovatis acute acuminatis basi cordatis crenato-serratis 3–5 cm. longis 2–3 cm. latis supra bullatis puberulis subtus griseo-tomentosis prominenter reticulatis a basi 3(–7)-nerviis; nervis a venis transversis connexis; corymbis laxiusculis paucicapitulatis; pedicellis patentibus saepe curvatis gracilibus pubescentibus 2–12 mm. longis; capitulis ca. 9 mm. altis 6 mm. diametro ca. 28-floris; involucri campanulato-subcylindrici squamis ca. 27 rigidiusculis pallidis eburneis lucidis 1(–3)-nerviis vel -striatis 4–5-seriatis regulariter gradatis caducis, extimis ovatis acutis, intermediis oblongis obtusis, intimis linearibus; summa parte axis post delapsum squamorum breviter cylindrica pedicello paullulo crassiore; corollis 4 mm. longis glabris; tubo proprio gracile 2.7 mm. longo; faucibus campanulatis 1.3 mm. altis; dentibus limbi brevibus recurvatis; pappi setis ca. 26 albidis 3.5 mm. longis apicem versus paullulo clavellatis stramineis hispidulo-scabratis; achaeniis nigris gracilibus 4–5-angulatis in angulis sursum minute scabratis apice cum nectario late breviterque cylindrico coronatis.— VENEZUELA: near Tovar, State of Mérida, *Fendler*, no. 638 (TYPE Gr.); Caracas, *Birschel* (Gr.); on the old road from Caracas to La Guaira, alt. 1100–1700 m., *Pittier*, no. 5880 (U. S., N. Y.).

E. (§ **Campyloclinium**) **zinniifolium**, spec. nov., fruticosum densissime fusco-tomentosum pilis glandulosis; foliis oppositis arcte sessilibus 5–7-nerviis elliptico-lanceolatis 7 cm. longis 3.5 cm. latis serratis (dentibus 0.5–1 mm. altis 3–4 mm. latis) apice angustatis obtusiusculis utrinque sordido-tomentellis; corymbis terminalibus vix pedunculatis ca. 10-capitulatis; capitulis ca. 100-floris 12–13 mm. altis; involucri campanulati squamis 22–25 subaequalibis lanceolato-oblongis basin versus 2–4-costatis (extimis 1–3 brevioribus) dorso pubescentibus et cum glandulis paucis sessilibus instructis margine erosis et glandulari-ciliatis; receptaculo valde convexo fere hemisphaerico glabro; corollis 6.3 mm. longis; tubo proprio 2.6 mm. longo gracillimo; faucibus 3.7 mm. longis campanulato-ampliatis; limbi dentibus 5 lanceolato-deltoideis acutis dorso villosis; achaeniis 2.7 mm. longis 5-costato-angulatis brunneis in costis sursum hispidulis in faciebus glabris basi callosis ad apicem cum disco parvo coronatis; pappi setis 20–25 albidis 5.5 mm. longis paullulo firmiusculis apicem versus sensim incrassatis scabridulis.— COLOMBIA: on the Sierra Nevada, alt. 2745–3050 m., Prov. of Rio Hacha, Dept. Magdalena, 1852, *L. Schlim*, no. 1812 (TYPE K., phot. Gr.).

This noteworthy species clearly belongs to the § *Campyloclinium* having the large heads and exceedingly convex receptacle of the group, but otherwise possessing many marked differences from previously described species. It was one of many plants obtained for horticultural purposes by J. Linden from northern South America in the 50's, but it has been impossible to find any horticultural records of the plant, which presumably failed to succeed in cultivation. The only field notes to be derived from the label are that the plant was shrubby and had roseate flowers. Whether the color was derived from the corollas or a composite impression of corollas and suffused involucral scales cannot now be told.

Fleischmannia repens, spec. nov., herbacea repens; caulibus pluribus teretibus a rhizomate horizontali curvato-adscendentibus 1.5–4 dm. longis usque ad inflorascentiam foliosis longiuscule sordideque pilosis, pilis patentibus moniliformibus; foliis oppositis lanceolatis petiolatis 7–9 cm. longis 1.2–1.9 cm. latis argute serratis apice attenuato-acuminatis basi integerrimis anguste cuneatis supra basin 3-nervatis utrinque laxe in nervis venisque pilosis subtus paullo pallidioribus; corymbis terminalibus compositis planiusculis multicapitulatis puberulis; pedicellis gracillimis; bracteis lineari-filiformibus minimis; capitulis parvis vix 5 mm. altis ca. 4 mm. diametro 17-floris; involucri campanulati squamis ca. 11 lineari-lanceolatis vel anguste oblongis acutiusculis ciliolatis 2–3-costato-nervatis una vel duabus extimis brevioribus caeteris subaequalibus ca. 3 mm. longis; corollis 2.8 mm. longis ut videtur albis vel pallide roseis glabris, tubo proprio gracillimo 1.5 mm. longo, faucibus abrupte campanulato-dilatatis, dentibus limbi 5 ovato-deltoideis acutiusculis patentibus; styli ramis filiformibus; antheris brevibus apice cum appendice oblongo-ovata

obtusa munitis; achaeniis 5-angulatis 1.2 mm. longis deorsum decrescentibus in costis hispidulis; pappi setis 5 delicatule capillaribus minute scabratis corollam aequantibus.— MEXICO: on wet rocks, Barranca de Tenampa, Zacuapan, Vera Cruz, March, 1910, *Dr. C. A. Purpus*, no. 4925 (TYPE Gr.).

This species, very naturally sent out as a *Eupatorium*, is clearly from its definite pappus-bristles of the genus *Fleishmannia*. It is, however, certainly distinct from any hitherto described species of the genus. While it approaches most nearly in its general habit and foliar characters *F. arguta* (HBK.) Robinson, it differs in many important characters. The heads are much more numerous, more definitely aggregated into flat-topped corymbs, and are much smaller. The florets are very much less numerous. The pubescence of the stem is of long conspicuous jointed hairs, while in *F. arguta* the stems are merely puberulent.

Kuhnia oreithales, spec. nov., herbacea erecta; caule tereti pluricostulato brevissime crispeque puberulo foliaceo 4–6 dm. vel ultra alto virgato vel supra mediam partem ramoso; ramis adscendente patentibus; foliis lineari-lanceolatis plerisque adscendentibus integerrimis minute puberulis utrinque viridibus subtus paullo pallidioribus crebre punctatis 5–8 cm. longis 2–6 mm. latis tenuibus 1-nerviis margine paullo revolutis; capitulis ca. 18-floris thyrsoideo-corymbosis graciliter pedicellatis nutantibus 11–12 mm. altis; involucri squamis interioribus anguste oblongis acutis tenuibus striatis viridibus vel partim purpureis subglabris sed apicem versus atomiferis et plus minusve ciliolatis, squamis extimis multo brevioribus subsquarroso-recurvatis; corollis ca. 6 mm. longis albidis vel purpureo-tinctis glabris sed in limbo extus atomiferis; achaeniis maturitate 6 mm. longis fusco-brunneis glabriusculis.— MEXICO: Chihuahua: near Colonia Garcia, 16 August, 1899, *Townsend & Barber*, no. 260 (TYPE Gr., U. S., Mo., etc.), distributed as *Coleosanthus corymbosus*, with which it has no close resemblance even of general habit, not to mention its plumose pappus. *K. oreithales*, in its thin smoothish leaves and in habit, resembles the northeastern *K. eupatorioides* L., but it differs from that species in its entire leaves and nodding heads, as well as its more acute inner involucral scales; and, of course, it is geographically remote. To *K. oreithales* may be referred the following specimens: near Colonia Garcia, 1–20 August, 1899, *E. W. Nelson*, nos. 6208 (Gr.), 6216 (Gr.); near Parral, 28 September, 1898, *E. H. Goldman*, no. 124 (Gr.); Sierra Madre and Sierra Santa Barbara, near La Providencia, alt. 1980–2440 m., *E. W. Nelson*, no. 5016 (Gr.).

II. A DESCRIPTIVE REVISION OF THE COLOMBIAN EUPATORIUMS.

In assembling data for a revision of the Eupatoriums of Mexico and Central America the writer was some months ago led to scrutinize the existing evidence as to their possible range-extensions into the northern portions of South America. The questions which arose were briefly, in how far is the Isthmus of Panama a path of plant-migration, or conversely, to what extent has this narrow neck of relatively low land, in recent geologic times, or the pre-existing marine channel, at a more remote epoch, acted as an effective barrier to plant-distribution?

Correlated with this somewhat abstract inquiry, arises a more concrete one when it is borne in mind that most of the larger South American collections have been studied in Europe, while nearly all recent work upon the Mexican and Central American floras has been done in the United States. Thus it becomes pertinent to inquire whether to any serious extent there has been unconscious duplication in the results — whether, for instance, of the many species and varieties described as new from Mexico and Central America, some portion may not precisely duplicate plants present in and perhaps already described from South American collections, which are sparingly if at all represented even in the larger herbaria on this side of the Atlantic.

At all events, to put classification of the very numerous Eupatoriums north of the Isthmus on a more secure footing, it seemed desirable, if not actually necessary, to give systematic attention at the same time to those of the adjacent portions of South America. For this purpose a provisional revision of the Colombian Eupatoriums was begun in October, 1917. To the usual difficulties incident to tropical work — deplorably inadequate material, scattered types, fragmentary literature, uncontrasted descriptions, faulty and inconsistent records — there has in the present instance been added the impossibility of communicating with several important European herbaria. However, by piecing together all available bits of fragmentary data, a treatment is here presented, which includes more than three times as many Colombian Eupatoriums as have been heretofore recorded in any single paper.

It has long been customary in most minor works dealing with tropical plants to confine the presentation to a bibliographic and synonymic enumeration of such previously described species, together with diagnoses of such novelties, as may have been found in a particular collection. Remarks on habit, habitat, dates of flowering, collectors' numbers, altitudinal ranges, etc., are usually added. Such papers are highly useful in large botanical establishments where numbered exsiccatae and copious literature are available, but apart from these aids they are exceedingly sterile. They fail signally to give assistance or encouragement to botanists resident in the tropics and to those collectors who are so situated as to be able to carry forward the all important field-work in the area treated. On this account it has seemed worth while to incorporate in the present paper not merely keys to sections and species, but at least brief descriptions of each species and variety enumerated.

As to the plants included, Colombian specimens of nearly all have been seen by the writer. A very few, however, have been included on the basis of past published records of their occurrence in Colombia or as it was formerly called New Grenada. Happily these reports rest in all cases upon work of such well known writers on the *Compositae* as the eldest DeCandolle, J. G. Baker, Weddell, Hieronymus, and Heering. In every instance in which no material has been personally seen, the authority for the occurrence in Colombia is duly cited. It is unfortunate that many specimens of marked character and considerable scientific interest, such as those of Triana in the herbarium of the Royal Gardens at Kew, are quite unaccompanied by data other than that they came from Colombia (New Grenada). It is possible that such specimens of Triana, Lobb, Moritz, and others, here recorded as lacking data of collection, may be present under corresponding numbers and with more complete labels in other herbaria. In case any such are found, the writer would welcome further information regarding them.

As the genus *Eupatorium* is of large size and extends from temperate North America to temperate South America; as it includes species of much diversity of habit from delicate annuals to small trees; and as it ranges from the seashore and tropical lowlands to alpine regions and areas of considerable aridity, it may be fairly regarded as an average sample from which to infer the relative endemism of particular regions. On this account it is believed that the following statistical memoranda will have a certain interest.

Of the 93 species of the genus, here presented as occurring within the limits of Colombia, no less than 53 or about 57 per cent are, so far as our present knowledge of the species goes, endemic, being unknown elsewhere. Of these 21 are new to science.

While some of these species will doubtless be found later in the very similar climatic conditions of adjacent portions of western Venezuela and of Ecuador, the number of local novelties found in recent collections from Colombia is such as to suggest that the proportion of endemism is likely to be increased rather than diminished by further exploration.

After deducting the endemic members of the genus there remain 40 species which occur both in Colombia and in other countries. These fall into several categories, as follows:

1). A group of 12 common species, of wide north and south distribution in tropical and subtropical America, extending in all instances from Mexico or Central America through Colombia, at least to Venezuela or Ecuador, and in most cases to Brazil, Peru, or Bolivia. These are *E. laevigatum, ivaefolium, odoratum, morifolium, microstemon, pycnocephalum, vitalbae, amygdalinum, solidaginoides, macrocephalum, nemorosum,* and *macrophyllum.* Among them, two or three (*E. microstemon, ivaefolium,* and perhaps *macrophyllum*) are so frequent about roadsides and cultivated grounds as to suggest that they have been more or less diffused as weeds, yet all are probably natural (that is to say native) components in the flora of Colombia.

2). The following 6 species extend from Colombia merely into Venezuela: *E. pellium, Moritzianum, Vargasianum, theaefolium, ibaguense,* and *stoechadifolium.*

3). In similar manner 13 species extend from Colombia merely southward into Ecuador along the Cordilleras, some of them reaching Peru or Bolivia: *E. leptocephalum, subscandens, origanoides, niveum, salicinum, Stuebelii, pseudoglomeratum, obscurifolium, fastigiatum, gracile* (doubtfully in its smoothish var. *epilobioides*), *Dombeyanum, azangaroense,* and *pichinchense.*

4). Only 5 species of *Eupatorium* occurring in Colombia are also found on any of the Greater Antilles, namely: *E. ivaefolium, odoratum, microstemon, ballotaefolium,* and *macrophyllum.* It will be observed that these are all common species of wide range. All except *E. ballotaefolium* (which in these larger islands of the West Indies occurs merely on Haiti) are found also in Mexico and Central America.

5). A very few species of Colombian Eupatoriums extend along the region of the "Spanish Main" and are also found on Margarita, Trinidad, or upon some of the Lesser Antilles. These are *E. corymbosum, iresinoides* (and its var. *glabrescens*), *inulaefolium,* and *ballotaefolium.* An analogous case is presented by *E. celtidifolium,* an arborescent species, of which the typical form is confined to the Lesser Antilles, while a perceptibly different pubescence-variety is found in Colombia.

6). Finally a few species, reaching their northwestern limit in Colombia, are somewhat widely distributed in tropical South America without passing north of the Isthmus of Panama or occurring (with the exception of *E. inulaefolium*) on any of the West Indian Islands. These are *E. articulatum* extending from Colombia both into Venezuela and southward into Peru; *E. scabrum*, a species often erroneously interpreted in the past, said by Baker to reach Guiana and Peru; *E. inulaefolium; E. punctulatum*, a species first collected presumably in eastern Brazil but said by Baker to occur also in Colombia; finally two species of weedlike character and belonging to the little Sect. *Praxelis*, namely *E. pauciflorum*, which ranges from Colombia to Brazil, and *E. kleinioides*, which extends from Colombia to Brazil and also in somewhat varying form to Peru.

When the Colombian Eupatoriums are thus analyzed, the following generalizations become possible.

a). The common element between the species of Colombia (93 in number) and those of the Mexicano-Central-American region (estimated at about 250) is surprisingly slight, amounting to only 12 species, that is to say about 13 per cent of the Colombian and only 4.8 per cent of the Mexicano-Central-American representation of the genus. Furthermore, these 12 species are all common and abundant plants also in other regions. All of them have been known for some decades and most of them from the earliest period in the botanical exploration of tropical America. It is also worthy of mention that no one of these species which extend into Colombia from north of the Isthmus finds its limit in Colombia. All pass entirely through the country and are found at least in Venezuela or Ecuador, and most of them in Brazil, Peru, and Bolivia as well.

b). The common element between Colombia and the Greater Antilles is considerably less, amounting only to 5 species. These also are plants which are abundant and widely distributed. All of them but one are identical with those common to Colombia and the Mexicano-Central-American region.

c). The common element between Colombia and the Lesser Antilles amounts to only 5 species. Of these, four are more or less abundant in coastal South America from the Isthmus to the mouth of the Orinoco, and the fifth (*E. corymbosum*) has been stated by Aublet to occur in French Guiana.

d). The element common to Venezuela (21 species when all are included even those of wide distribution and in some cases of weedy character) somewhat exceeds the element common to Ecuador (19 species). On the other hand the actual affinities of the Colombian Eupatoriums, when determined by the more characteristic and more certainly native species of limited range, are more strongly Ecuadorian than Venezuelan.

There seems no reason to suppose that the statistical relations here presented on the basis of this large and diversified genus will not be found to hold their approximate ratio in many other groups. Unfortunately the present state of knowledge regarding the details of plant-distribution in Colombia, as well as of the geological, meteorological, and physiographic conditions, is still much too slight to permit generalization regarding ecological relations or soil-influence in determining the present flora.

EUPATORIUM [Tourn.] L. Heads homogamous, (1–4)5–∞-flowered. Involucre cylindrical to campanulate; the scales of indefinite number, usually numerous, commonly graduated and appearing to be arranged in 2–8 series, the inner progressively longer, more rarely almost all subequal and with only a few (1–3) of the outermost considerably shorter. Receptacle flat or in varying degree convex to conical, glabrous or in one section pubescent, calvous. Corolla tubular, with or without a perceptibly enlarged campanulate, turbinate, or cylindrical throat; the limb (4–)5-toothed, regular. Anthers mostly connate but sometimes nearly or quite free, rounded (to rarely and obscurely cordate or subsagittate) at the base, provided at the summit with an ovate or oblong mostly obtuse rarely retuse membranaceous appendage. Style-branches much exserted, the appendage elongate, filiform or more commonly somewhat clavate, smooth or microscopically papillose. Achenes 5-angled, the angles usually rib-thickened and of modified texture, color, or pubescence, the intervals flat or often concave, occasionally provided with lesser ribs intermediate between the main ones. Pappus of 10–∞ bristles, for the most part nearly or quite equalling the corolla; the bristles truly capillary or slightly firmer, white or sordid, sometimes tinged with rose or purple, rarely tawny, usually (at least when examined with a compound microscope) hispidulous, never strongly plumose.— Sp. Pl. ii. 836 (1753); L. f. Suppl. 354 (1781); HBK. Nov. Gen. et Spec. iv. 105–134 (1820), excl. certain species; DC. Prod. v. 141–186 (1836); Benth. & Hook. f. Gen. ii. 245 (1873); Bak. in Mart. Fl. Bras. vi. pt. 2, 274–365, t. 76–96 (1876); Klatt in Engl. Bot. Jahrb. viii. 33–36 (1887); Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 138 (1890); Hieron.

in Engl. Bot. Jahrb. xix. 45 (1894), xxi. 329–333 (1895), xxix. 5–15 (1900), xxviii. 564–576 (1901), xl. 369–389 (1908); Heering in Fuhrmann & Mayor, Mém. Soc. neuchât. Sci. Nat. v. 418–421 (1913). For extended synonymy, see Dalla Torre & Harms, Gen. Siphonog. 527 (1905).— Mostly perennial herbs or erect shrubs, a few annuals, a few arborescent or even arboreous, a few shrubby climbers (leaning rather than twining). Leaves chiefly opposite, rarely alternate, sometimes scattered, in a few species verticellate or perfoliate, in contour ranging from filiform to orbicular, in texture from delicately membranaceous to coriaceous or rarely to fleshy. Florets clear white, pink, purple, or blue, rarely greenish- or yellowish-white.

A huge genus, most copiously distributed, both as to individuals and species in the warmer parts of America, from Mexico to Brazil, also well represented in temperate North America and extra-tropical South America, and sparingly so in Eurasia, but nearly absent from Africa and lacking in Australia.

KEY TO SECTIONS.

- *a.* Receptacle glabrous *b.*
  - *b.* Receptacle flat or nearly so *c.*
    - *c.* Involucre cylindrical (2–)3–5 times as long as thick; scales closely imbricate in several regularly graduated series, at maturity readily deciduous or sometimes caducous, firm in texture, somewhat scarious except toward the usually obtuse or rounded and commonly subherbaceous tip . . . . Sect. I. CYLINDROCEPHALA (p. 270).
    - *c.* Involucre campanulate or turbinate (rarely cylindrical but then with scales in fewer series and less closely imbricated than in the preceding section), seldom more than twice as high as thick; scales persisting until after the fall of the achenes *d.*
      - *d.* Scales very unequal, the outer gradually shorter in 3–several series . . . . Sect. II. SUBIMBRICATA (p. 281).
      - *d.* Scales subequal in 1–2 scarcely imbricated series, but often 1–3 of the outermost scales considerably smaller Sect. III. EXIMBRICATA (p. 303).
  - *b.* Receptacle strongly convex, hemispherical or conical *e.*
    - *e.* Scales imbricated in several series, readily deciduous or caducous at maturity, commonly falling away before the achenes. Heads few, separate, long-peduncled. Annual herbs . . . . Sect. IV. PRAXELIS (p. 318).
    - *e.* Scales persistent, at least until after the fall of the achenes. Chiefly perennial herbs or shrubs *f.*
      - *f.* Heads small (usually 4–7 mm. high), mostly 15–30-flowered. Scales 2–5-ribbed, usually graduated in 3–4 series, mostly attenuate to a subulate or at least acute tip . . . . Sect. V. CONOCLINIUM (p. 320).
      - *f.* Heads large (1 cm. or more in height), 40–120-flowered. Scales subequal in length, finely nerved or many-striate rather than strongly ribbed. . Sect. VI. CAMPULOCLINIUM (p. 325).
- *a.* Receptacle hairy, convex . . . . Sect. VII. HEBECLINIUM (p. 327).

Sect. I. CYLINDROCEPHALA DC. Heads cylindrical (2–)3–5 times as long as thick, 5–75-flowered; scales many-seried, regularly graduated, closely imbricated, concave, firmish in texture, often promptly deciduous, usually pale or stramineous except at the mostly darker often subherbaceous generally obtuse or rounded tip. Receptacle small, flat or nearly so, glabrous.— Prod. v. 141 (1836). *Eupatorium* ser. *Imbricata* DC. l. c. in part. *Eupatorium* sect. *Imbricata* (DC.) Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 139 (1890). *Osmia* Sch. Bip. Pollichia, xxii.–xxiv. 250 (1866). *Eupatorium* sect. *Osmia* (Sch. Bip.) Benth. ex Bak. in Mart. Fl. Bras. vi. pt. 2, 275 (1876).— Chiefly shrubby plants of warm climates.

KEY TO SPECIES.

a. Leaves cordate, sessile or nearly so, deflexed, somewhat rigid, bullate above . . . . 1. *E. bullatum.*
a. Leaves petiolate or cuneately narrowed to a subsessile base *b.*
  b. Pedicels sulcate-angulate, glabrous *c.*
    c. Heads in dense flattish or moderately convex corymbs *d.*
      d. Scales of the involucre oblong, rounded or subtruncate or even slightly retuse at the thinnish-margined apex; their nerves straight or even slightly diverging at the tip; leaves lanceolate, long-acuminate *e.*
        e. Heads thickish-cylindric to subcampanulate-cylindric, 45–75-flowered . . . . 2. *E. pellium.*
        e. Heads slender-cylindric, about 20-flowered . . . . 3. *E. Moritzianum.*
      d. Scales ovate-oblong, slightly thickened and with nerves somewhat convergent toward the tip; leaves ovate, never long-acuminate . . . . 4. *E. laevigatum.*
    c. Heads in an elongated loose opposite-branched leafy-bracted panicle *f.*
      f. Leaves coarsely pellucid-punctate; veinlets scarcely at all translucent; heads about 26-flowered . . . . 5. *E. chrysostictum.*
      f. Leaves not punctate; veinlets forming a translucent network; heads about 12-flowered . . . . 6. *E. diaphanophlebium.*
  b. Pedicels pubescent or puberulent (smoothish and essentially terete in *E. subscandens*) *g.*
    g. Scales (pale in color) provided at tip with a small but conspicuous lance-linear subherbaceous spreading or reflexed appendage . . . . 7. *E. uromeres.*
    g. Scales sometimes changed in texture toward the tip but in no case bearing a narrow appendage *h.*
      h. Leaves (ovate, never at all rhombic or hastate) rounded at base, petiolate (sometimes in *E. columbianum* abruptly short-acuminate on one or both sides of the insertion from an otherwise rounded base) *i.*
        i. Involucral scales dorsally woolly near the tip . . 8. *E. columbianum.*
        i. Scales glabrous *j.*
          j. Leaves merely acute or acutish, tomentose beneath, about 2 cm. long; petioles about 3 mm. long . . . . 9. *E. hypericifolium.*

j. Leaves caudate-acuminate, 5–10 cm. long; petioles about 1 cm. long *k.*

k. Pedicels mostly curved-ascending; leaves pubescent on the nerves and veins beneath, dull above 18. *E. subscandens.*

k. Pedicels straight; leaves smooth and shining above, nearly glabrous beneath *l.*

l. Leaves coarsely pellucid-punctate; veinlets scarcely translucent; heads about 26-flowered 5. *E. chrysostictum.*

l. Leaves not punctate; veinlets forming a translucent network; heads about 12-flowered 6. *E. diaphanophlebium.*

h. Leaves narrowed to an acute or at least obtusely pointed (not rounded) base *m.*

m. Scales much changed in texture toward the tip, being there subherbaceous, pubescent, and often somewhat squarrose *n.*

n. Scales, at least the middle and inner, acute; heads more than 3 times as long as thick; leaves ovate-lanceolate .... 10. *E. iridolepis.*

n. Scales subtruncate or rounded; heads about twice as long as thick; leaves linear- to oblong-lanceolate .... 11. *E. ivaefolium.*

m. Scales little changed in texture (although often somewhat darker) toward the closely appressed tip *o.*

o. Leaves thickish but not rigid, small (2–4 or rarely –6 cm. long, including the short petiole), tomentellous above, canescent-tomentose beneath *p.*

p. Leaves entire; achenes 3 mm. long, pubescent on the faces as well as the ribs .... 12. *E. leivense.*

p. Leaves crenate-serrate; achenes 2.2–2.5 mm. long, slightly hispidulous on the ribs only 13. *E. tacotanum.*

o. Leaves somewhat firm in texture, lanceolate to ovate, 4–6 cm. long, conspicuously bullate-rugose and scabrid above, coarsely villous on prominently exserted ribs and veins beneath, the hairs long, dark, and articulated .... 14. *E. scabrum.*

o. Leaves rhombic-ovate to lanceolate, often with a slight hastate tendency, never strongly bullate-rugose above, nor with conspicuously exserted veins beneath *q.*

q. Heads sessile in pedicellate glomerules together forming dense corymbs .... 15. *E. punctulatum.*

q. Heads, at least most of them, pedicelled *r.*

r. Heads very slender, 6–8-flowered, acute in bud *s.*

s. Petiole relatively short, about one sixteenth as long as the blade .... 16. *E. leptocephalum.*

s. Petiole (1–2 cm. long) about one fourth as long as the blade .... 17. *E. barranquillense.*

r. Heads thicker, obtuse or obtusish in bud, 10–35-flowered; petiole one fifth to one third as long as the blade *t.*

i. Leaves subchartaceous, subglabrous, ovate to ovate-lanceolate, attenuate, rather obscurely serrate (none in the least hastate); pedicels usually 1–1.5 cm. long, mostly curved or hooked................18. *E. subscandens.*
i. Leaves membranaceous, rhombic- to deltoid-ovate, rather coarsely and often somewhat hastately crenate-toothed, densely and softly villous or even subtomentose beneath; pedicels usually 2–8 mm. long, mostly straight......................19. *E. odoratum.*
h. Leaves deltoid-ovate, the wide base of the blade subtruncate or shallowly and broadly cordate (sometimes with a slight acumination at the insertion..20. *E. corymbosum.*

1. **E. bullatum** Klatt. Grayish-green shrub 4 dm. or more in height, with erect or ascending leafy branches; leaves opposite, small (1–2 cm. long), ovate, subsessile by a cordate base, nearly or quite entire, thick, furrowed, warty, finely puberulent to glabrate and lucid above, gray-velvety beneath, commonly deflexed at maturity, their margins revolute; heads cylindric, erect, in small crowded compound cymes; scales closely appressed, obtuse, mucronulate, often brown-tipped; corollas white (Rusby & Pennell).— Klatt in Engl. Bot. Jahrb. viii. 34 (1887). *E. scabrum* HBK. Nov. Gen. et Spec. iv. 119 (1820), not. L. f. *E. Kunthianum* Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xxviii. 568 (1901).— A highly characteristic species of restricted range.

–Cundinamarca: in small open woods near Facatativá, alt. 2600 m., *Lehmann*, no. 2544 (fragm. and sk. Gr.); on high plains of Bogotá near Santa Fé, *Humboldt & Bonpland*, acc. to Hieronymus, l. c. (as *E. Kunthianum*); Montserrate near Bogotá, *Holton*, no. 315 (K., N. Y.); dry shrubby slope above Bogotá, *Pennell*, no. 2093 (Gr.); dry cañon above Bogotá, alt. 2600–2700 m., *Pennell*, no. 2137 (Gr.); dry open hillsides southwest of Sibate, alt. 2700–2800 m., *Pennell*, no. 2393 (Gr.).

2. **E. pellium** Klatt. Glabrous and somewhat sticky shrub 9–15 dm. high with round smooth grayish-brown ascending very leafy branches; leaves (often nigrescent in drying) opposite, lanceolate, serrate, attenuate, often conduplicate and falcate, cuneate at base to a short petiole, paler beneath, usually 3-nerved from somewhat above the base after 1–3 pairs of more obscure lateral veins have left the midrib; involucre ovoid in bud, at maturity campanulate, 5–7 mm. thick; florets 45–75.— Ann. k. k. Naturh. Hofmus. Wien, ix. 357 (1894).

Magdalena. Santa Marta, *Purdie* (K., Gr.); Onaca, alt. 762 m., *H. H. Smith*, no. 616 (Gr., N. Y., Mo.).
[Western Venezuela.]

3. **E. Moritzianum** Sch. Bip. Glabrous and slightly viscid leafy-branched shrub, turning dark in drying and in all respects very like the preceding species; heads smaller, about 20-flowered; involucre about 3 mm. thick, cylindric, with a shortly pointed base.— Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xxviii. 565 (1901).

HUILA: Eastern Cordillera near Neiva, *Rusby & Pennell*, no. 1056 (N. Y.).

DEPARTMENT (EL VALLE OR CALDAS?) NOT INDICATED: in Altamira above Tolima, alt. 800–1500 m., *Lehmann*, no. 8725 (N. Y.).

[Western Venezuela.]

Likely to prove a mere variety of the preceding, but convincing intermediates not as yet discovered.

4. **E. laevigatum** Lam. Viscid shrub, 1–3 m. high, glabrous throughout; branches and pedicels angled; leaves light green, opposite, rhombic-ovate to ovate-oblong, thickish, serrate, 3-ribbed from the entire mostly cuneate base, transversely veined between the ribs; heads (sessile to rather long-pedicelled) numerous, in dense moderately convex corymbs; flowers dull white.— Encyc. ii. 408 (1786); HBK. Nov. Gen. et Spec. iv. 117 (1820); Hieron. in Engl. Bot. Jahrb. xxviii. 567 (1901). *E. conyzoides* Klatt in Engl. Bot. Jahrb. viii. 34 (1887), not Mill. nor Vahl.

CAUCA: in bushy places on mountain meadows about La Teta and Buenos Aires, *Lehmann*, no. 5188, acc. to Hieron. l. c.; among shrubs on savannahs, alt. 1600 m., Tocotá, *Lehmann*, no. 3440 (Gr.); Cordillera Occidental, in clayey soil, alt. 1600 m., *Langlassé*, no. 70 (Gr.).

HUILA: about La Plata, alt. 1000–1400 m., *Lehmann*, no. 8447, acc to Hieron. l. c.

TOLIMA: in coffee-plantation, "La Trinidad," Libano, alt. 1000–1200 m., *Pennell*, no. 3309 (Gr.).

Widely distributed from Mexico to Argentina, characteristic in habit and fairly constant.

5. **E. chrysostictum** Robinson. Subglabrous, erect perennial herb or very likely shrub; branches smooth, terete; leaves opposite, ovate, caudate-acuminate, rounded at base, obscurely and remotely mucronulate-denticulate on the revolute margin, 1 dm. long, half as broad, green and glabrous on both surfaces, shining above, dull and densely punctate beneath, the dots being orange and translucent; petiole 1–1.5 cm. long; heads cylindric, about 26-flowered, 7 mm. in diameter; scales stramineous, rounded and mucronulate at the closely appressed tip; flowers inferred to be white.— Proc. Am. Acad. liv. 240 (1918).

MAGDALENA: Santa Marta, *H. H. Smith*, no. 660 (Gr., Mo.).

6. **E. diaphanophlebium** Robinson. Similar in habit and in most features to the preceding, more slender; leaves also ovate, caudate-acuminate, rounded at base, opposite, on short petioles, but smaller, 5–7 cm. long, half as wide, not translucent-punctate but with a distinctly pellucid network of small veins; heads smaller, 4 mm. in diameter; branches of the panicle dividing three or more times, many-headed.— Proc. Am. Acad. liv. 242 (1918).

MAGDALENA: Santa Marta, *H. H. Smith*, no. 1990 (Gr., N. Y.).

7. **E. uromeres** Robinson. Slender shrub with grayish-green foliage and terete flexuous presumably reclining stems; leaves opposite, ovate, acute, rounded or shortly cuneate at base, undulate-serrulate, 4–6 cm. long, 2–3 cm. wide, thin, dull green and finely papillose above, paler, softly and rather copiously pubescent on the nerves and netted veins beneath; cymes 3–5-headed, opposite, widely spreading, their branches and diverging pedicels very slender, crisped-pubescent; heads campanulate, 7 mm. high, 4 mm. thick, about 45-flowered; scales ivory-white, with a dark mid-vein becoming broader upward and terminating in a narrow spreading or deflexed caudate herbaceous appendage.— Proc. Am. Acad. liv. 260 (1918).

MAGDALENA: Occasional in thickets and dry forest below 915 m., Santa Marta, *H. H. Smith*, no. 505 (Gr., N. Y., Mo.); dry forest near Bonda, Aug., *H. H. Smith*, no. 659 (N. Y.); near Onaca, alt. 770 m., Dec., *H. H. Smith*, no. 658 (N. Y.).

8. **E. columbianum** Heering. Sordid-pubescent shrub; branches 6-ribbed and deeply channeled between the ribs; leaves opposite, petiolate, large, ovate, 1–1.6 dm. long, about half as wide, acuminate, coarsely serrate, pubescent on nerves and veins but otherwise subglabrous and in age somewhat rugose or bullate above, sordid- or rusty-tomentose beneath, rounded at base or sometimes shortly cuneate-decurrent on one or both sides of the petiole; heads very numerous, sessile or nearly so in dense compound round-topped corymbs; scales many-seried, 3-nerved, darkened toward the obtusely pointed more or less hairy tip; florets about 12; corollas pale violet or white.— Mém. Soc. neuchât. Sci. Nat. v. 421 (1913).

ANTIOQUIA and TOLIMA: common everywhere to 2000 m., *Mayor*, no. 629 (acc. to Heering, l. c.).

CUNDINAMARCA: Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, no. 88 (Gr., U. S.).

WITHOUT LOCALITY: *Triana*, no. 1238 (K., N. Y.).

9. **E. hypericifolium** HBK. Shrub, becoming 4 m. in height (Lehmann), with ascending terete slightly furrowed sordid-tomentellous at length glabrate branches; leaves opposite, short-petioled, ovate, acute, entire, 2–2.5 cm. long, 9–15 mm. wide, rounded at base, sordid-pubescent and at maturity more or less glabrate above, rusty-velvety beneath, 3-nerved from the base; petiole slender 2–3(–6) mm. long; heads cylindric, erect, 14 mm. high, 4–5 mm. thick, pedicelled, in small corymbs terminal on the branches; scales stramineous 3(–5)-nerved, brownish toward the tip, the outer obtusely and the inner acutely pointed; corollas lilac (Lehmann) or blue (Rusby & Pennell); achenes black, 5–6 mm. long, upwardly hispid on the sharp angles.— Nov. Gen. et Spec. iv. 118 (1820); Hieron in Engl. Bot. Jahrb. xxviii. 567 (1901). *E. conyzoides*, var. *incanum* Hieron. l. c. xix. 45 (1894), acc. to Hieron. l. c. xxviii. 567 (1901).

CUNDINAMARCA: among shrubs on savannahs near Pacho, alt. 1700–2200 m., *Lehmann*, no. 7494 (N. Y.).

HUILA: on the Cordillera Oriental, near Neiva, *Rusby & Pennell*, no. 431 (N. Y.).

WITHOUT LOCALITY: *Humboldt & Bonpland* (Par., phot. Gr.).

10. **E. iridolepis** Robinson. Shrub 12–15 dm. high; stem flexuous, gray-tomentulose (the hairs curved); leaves opposite, ovate, petiolate, crenate-serrate except at the long-acuminate apex and rounded or abruptly cuneate base where entire, 3-nerved above the base, 6–7 cm. long, 2.4–3 cm. wide, minutely hirtellous above, softly pubescent and orange-punctate beneath; corymbs terminal, rather dense, convex, many-headed; heads about 10-flowered, 9.5 mm. high, 3–4 mm. in diameter, sessile by 3's and 4's at the tips of the branchlets of the inflorescence; scales of the slender-cylindric involucre 4–5-seriate, narrowly oblong, white and shining toward the base, subherbaceous and green or (the innermost) rose-purple at the tip, the intermediate often more or less squarrose at the subherbaceous acutish and somewhat tomentellous apex; corollas roseate; achenes 3.3 mm. long, hispidulous on and between the ribs.— Proc. Am. Acad. liv. 247 (1918).

MAGDALENA: in one place only, on open hillside, edge of forest, Las Nubes, alt. 1370 m., December, *H. H. Smith*, no. 615 (Gr.).

11. **E. ivaefolium** L. Erect, subherbaceous or distinctly shrubby, 4–12 dm. high, harshly pubescent, the hairs jointed and curved; leaves opposite, lance-linear, 3-nerved, often proliferous in the axils,

3–7 cm. long, 5–22 mm. wide, the upper subentire, the lower coarsely toothed; heads in trichotomous open flattish-topped compound cymes; involucre shortly cylindric 5–8 mm. long, half as thick; outer and intermediate scales provided with subherbaceous and often slightly squarrose subtruncate erose tip, the innermost commonly somewhat petaloid and lilac at the apex; florets lilac-purple; achenes black, 2.4 mm. long, with light-colored smooth or somewhat roughened angles.— Syst. ed. 10, 1205 (1759) [as *E. iuaefolium*]; Amoen. Acad. v. 405 (28 Nov. 1759) [as *E. ivifolium*]; Sp. Pl. ed. 2, ii. 1174 (1763).

MAGDALENA: locally common, generally in ravines, edge of forest or on open campo, alt. 305–915 m., Onaca, *H. H. Smith*, nos. 533 (Gr., U. S.) and 617 (Gr., U. S.).

[Miss. to Tex., Cub., Jam., Lesser Antil., Mex. to Boliv. and Braz.]

12. **E. leivense** Hieron. Erect shrub, gray-tomentulose, with ascending branches; leaves opposite, lanceolate to ovate, entire, acute or obtuse at apex, cuneate at base, softly though shortly grayish-velvety especially beneath, 2–5 cm. long, 1–2.4 cm. wide; heads mostly subsessile disposed by 3's to 5's in a broad flattish leafy-bracted compound terminal cyme; involucres about 6 mm. long, 2 mm. in thickness, 8–11-flowered; scales stramineous, slightly 3-nerved, ciliolate, somewhat darkened and dorsally hairy toward the bluntish tip.— Hieron. in Eng. Bot. Jahrb. xxi. 329 (1895).

BOYACÁ: near Leiva, *Stübel*, no. 152a (Berl., fragm. and phot. Gr.).

CUNDINAMARCA: near Bogotá, alt. 2600 m., *Bros. Apollinaire & Arthur*, no. 45 (U. S., fragm. Gr.).

13. **E. tacotanum** Klatt. Erect, often flowering at 6 dm. and essentially herbaceous (Langlassé, Pennell), but under favorable conditions becoming a shrub 2 m. or more in height (Lehmann), dark grayish-puberulent above, paler, velvety, and obviously reticulate-veiny beneath, 3-nerved from above the base; heads pedicelled in flattish-topped compound corymbs; pedicels 3–10 mm. long; involucre 7 mm. high, 2–3 mm. in diameter; scales oblong-lanceolate, mostly 1-nerved, all but the outermost smooth or nearly so, the intermediate lanceolate-linear, acutish, the innermost acute and purplish at the tip; corollas pale lilac.— Klatt in Engl. Bot. Jahrb. viii. 35 (1887); Hieron. in Engl. Bot. Jahrb. xxviii. 567 (1901); Heering, Mém. Soc. neuchât. Sci. Nat. v. 420 (1913).

CUNDINAMARCA: open slopes, Melgar, alt. 1300–1500 m., *Pennell*, no. 2843 (Gr.), herbaceous, flowers "blue."

HUILA: on dry hills around Huila, in the valley of the Rio Paez, alt. 1600–1900 m., *Pittier*, no. 1297 (U. S.), flowers "pink."

EL VALLE: La Paila, *Holton*, no. 316 (N. Y.); in bushy places on savannahs, alt. 1600 m., around Tocotá, *Lehmann*, no. 3424 (Gr.); around Calí, western side of Cauca Valley, alt. 1000–1200 m., *Pittier*, no. 654 (U. S.), flowers "azure-blue."

CAUCA: around Tacueyo, Rio Palo Valley, Central Cordillera, alt. 1800 m., *Pittier*, no. 1051 (U. S.), flowers "purple."

WITHOUT LOCALITY: *Linden*, no. 985 (K.) in part; *Triana*, no. 1204 (N. Y.) in part.

Forma **apodum** Robinson. Heads nearly all closely sessile in 2–4-headed glomerules, these disposed in more or less open flat-topped cymose panicles; a few pedicels developed to 2.8 mm. in length.— Proc. Am. Acad. liv. 259 (1918). *E. tacotanum* Klatt, l. c. in part.

EL VALLE: in bushy places on savannahs, alt. 1600 m., about Tocotá, *Lehmann*, no. 3438 (Gr.).

A shrub, attaining 3 m. in height; flowers lilac-red and very fragrant (Lehmann).

Var. **trineurolepis** Robinson. Scales of the involucre chiefly 3-nerved, somewhat more oblong and obtuse than in the typical variety, tomentulose near the tip; corollas mauve-violet (Langlassé), blue or white (Pennell).— Proc. Am. Acad. liv. 259 (1918).

CUNDINAMARCA: dry open hill, Icononzo, alt. 1000–1200 m., *Pennell*, no. 2801 (Gr.), herbaceous.

TOLIMA: open rocky hill, Honda, alt. 300–500 m., *Pennell*, no. 3564 (Gr.), herbaceous.

EL VALLE: in clayey soil, alt. 800 m., Papagayeros, *Langlassé*, no. 9 (Gr.); El Saladito above Calí, Cordillera Occidental, alt. 1600 m., *Pittier*, no. 757 (U. S.).

WITHOUT LOCALITY: *Triana*, no. 1204 (K., N. Y.) in part; *Lehmann*, no. 5680 (N. Y.); *Linden*, no. 985 (K.) in part.

14. **E. scabrum** L. f. Shrubby, sordid-villous with long dark jointed spreading hairs; branches ribbed and furrowed, leafy; leaves opposite, short-petioled, ovate to ovate-lanceolate, acute to acuminate at both ends, 3-ribbed from the base, bullate-rugose and hirtellous above, coarsely reticulate-veiny and spreading sordid-villous beneath, 6–7 cm. long, 2.3–3 cm. wide, sparingly and rather finely serrate in the middle of each side, nearly or quite entire toward each end; heads

very numerous in dense round-topped compound corymbs; involucres 7–8 mm. long, 2–3 mm. thick; scales appressed in 4–5 series, 3–5-nerved, dark and slightly tomentulose at the rounded tip, the margin often purple; florets violet-blue (Pennell).— Suppl. 354 (1781); J. E. Sm. Ic. iii. t. 67 (1791). *Osmia scabra* (L. f.) Sch. Bip. Pollichia, xxii–xxiv. 253 (1866).

CUNDINAMARCA: on mountains east of Bogotá, *Holton*, no. 314 (Gr.); Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, no. 95 (Gr., U. S.); cañon, Chapinero, alt. 2700–2800 m., *Pennell*, no. 2042 (Gr.).

WITHOUT LOCALITY: *Mutis* (Linnean Soc. Herb., phot. Gr.).

[By Baker in Mart. Fl. Bras. vi. pt. 2, 299 (1876) this species is said to range to British Guiana and Peru.]

For a species of such early date this was accurately described in considerable detail, but it has been much misinterpreted by continental writers; thus Kunth mistook for it the very different plant later described first as *E. bullatum* by Klatt and later as *E. Kunthianum* by Hieronymus, who took up a manuscript name of Schultz-Bipontinus. Both Klatt and Hieronymus appear to have been misled by an earlier determination of Schultz into supposing *E. scabrum* to have been represented by Moritz's no. 1365 from Venezuela (*E. meridense* Robinson), a plant very different from the fortunately preserved type of *E. scabrum* which fully confirms the diagnosis of Linnaeus filius.

15. **E. punctulatum** DC. Shrubby; stem round and nearly smooth; leaves opposite, ovate-elliptic or -oblong, acute or acuminate at both ends, rather finely serrate with somewhat distant teeth, 3-nerved, subglabrous, punctate beneath, 1 dm. long, 2.5 cm. wide; heads cylindric, 8–9-flowered, 8 mm. long, sessile in fascicles of 3–5 at the ends of the branchlets of ample flattish terminal corymbs; scales striate, closely appressed in about 4 series, finely 3(–5)-nerved, darkened toward the obtuse or rounded tip; achenes glabrous.— Prod. v. 147 (1836); Bak. in Mart. Fl. Bras. vi. pt. 2, 299 (1876).

NEW GRENADA: *Linden*, no. 823, acc. to Bak. l. c.

[Eastern Brazil, acc. to Bak. l. c.]

No Colombian material of this species has been seen by the writer, but the original character, here summarized, has been subject to control from a clear photograph (in the Gray Herbarium) of the fragmentary type in the DeCandollean Herbarium in Geneva.

16. **E. leptocephalum** DC. Shrubby, with reddish or purplish branches sparingly puberulent with short curved subappressed non-

glandular hairs; leaves opposite, narrowly ovate-lanceolate to lanceolate, serrate, caudate-attenuate to a very narrow usually falcate tip and gradually cuneate to a shortly petioled base, thin, deep green above, scarcely paler beneath; heads very slender, acute in bud, 7–8-flowered, some sessile but most of them slender-pedicelled, in leafy-bracted panicles composed of small corymbosely disposed cymes; involucre about 7 mm. long; scales (1–)3-nerved, white, with acutish greenish tips, essentially glabrous.— Prod. v. 148 (1836). *Osmia leptocephala* (DC.) Sch. Bip. Pollichia, xxii.–xxiv. 253 (1866).

El Valle: Cuesta de Tocotá, Cordillera Occidental, alt. 1500–1900 m., *Pittier*, no. 735 (Gr.).
[Ecuador and Peru.]

17. **E. barranguillense** Hieron. Shrub, 3 m. high, with subscandent stems and glabrate divaricate slightly furrowed branches; leaves opposite, rhombic-ovate, acuminate at the apex, usually cuneate at base, 6–7 cm. long, about half as wide, 3-nerved, very slightly pubescent on both surfaces, scarcely paler and punctate beneath; petiole 0.8–1.8 cm. long; heads 6–8-flowered, very slender, in flattish-topped corymbs; involucre-scales pale, greenish-white, 5–7-nerved, (for the §) loosely imbricated, not much darkened toward the acutish somewhat ciliated tip, slightly puberulent on the back; florets whitish. — Hieron. in Engl. Bot. Jahrb. xxviii. 564 (1901).

Atlantico: in open bushy places around Barranguilla, flowering Nov.–Dec., *Lehmann*, no. 7953 (Berl., fragm. and phot. Gr.).

18. **E. subscandens** Hieron. Closely branched, subherbaceous to somewhat woody, at length reclining or weakly climbing, 2.5 m. high, with terete soon almost glabrate stem and sap-green foliage; leaves lance-ovate, opposite, petiolate, entire or very sparingly and remotely small-toothed, caudate-acuminate, often falcate, 3-nerved, rounded or shortly pointed at base, sparingly hirtellous above, more or less pubescent on the veins beneath; branches divaricate; heads cylindric, 1 cm. long, 4–5 mm., in diameter; involucral scales in about 4 ranks, 3-nerved, rounded at the closely appressed and darkened tip; pedicels mostly curved or hooked, 1–1.5 cm. long; corollas lilac-blue (Lehmann).— Hieron. in Engl. Bot. Jahrb. xxii. 742 (1897). *E. conyzoides*, var. *pauciflorum* Hieron. l. c. xix. 45 (1894), not Bak. *E. pulchellum* Klatt in Engl. Bot. Jahrb. viii. 35 (1887), not HBK. *E. tequendamense* Hieron. l. c. xxix. 6 (1900). *E. elongatum* Willd.

ex Hieron. l. c. (a name of no possible validity and in its late publication a needless increase to synonymy).

CUNDINAMARCA: in clearings near Tequendama, alt. 2300 m., *Lehmann*, no. 2491 (Gr.); near Pacho, alt. 1500–2000 m., *Lehmann*, no. 7475 (Berl., phot. Gr.).
[Bolivia.]

19. **E. odoratum** L. Much branched shrub 1–2 m. high, suberect or slightly scandent or reclining on neighboring vegetation; stems terete, spreading-villous; internodes often 1 dm. or more in length; branches divaricate, often curved upward; leaves deltoid- or rhombic-ovate, 7–10 cm. long, 3–4 cm. wide, long-acuminate, subentire to coarsely and often somewhat hastately few-toothed chiefly where broadest, entire at the abruptly narrowed though mostly acute base, sparingly villous above, moderately pubescent to velvety beneath; 3-nerved from the base; heads 20–35-flowered, in trichotomous convex corymbs; florets pale lilac to bright purplish-blue, varying (rarely) to pink or (frequently) to white, usually fragrant.— Syst. ed. *10, 1205 (1759)*, Amoen. Acad. v. 405 (1759), & Spec. Pl. ed. 2, ii. 1174 (1763); Benth. Pl. Hartw. 198 (1845); Urb. Symb. Ant. iv. 623 (1911). *E. conyzoides* Mill. Dict. ed. 8, no. 14 (1768), both as to descript. and ref. to Sloane, which in its turn goes back to same fig. of Plukenet. *E. conyzoides* Vahl, Symb. iii. 96 (1794); Schrank, Pl. Rar. Hort. Monac. t. 85 (1819); Bak. in Mart. Fl. Bras. vi. pt. 2, 277 (1876), where several not very satisfactory varieties are indicated; Heering, Mém. Soc. neuchât. Sci. Nat. v. 420 (1913).

MAGDALENA: Quemadito, *André*, no. 220 (Gr.); in a clearing at Las Nubes, alt. 1372 m., *H. H. Smith*, no. 636 (Gr.); campo near Onaca, alt. 762 m., *H. H. Smith*, no. 637 (N. Y.); common in thickets, Bonda, alt. 75 m., *H. H. Smith*, no. 506 (Gr., U. S.).
CUNDINAMARCA: in woods near Villeta, *Hartweg*, acc. to Benth. l. c.
ANTIOQUIA: river-flat, alt. 150 m., Brazuela de Perales, Rio Magdalena, *Pennell*, no. 3690 (Gr.), fl. violet.
TOLIMA: in loam on slope along river, Honda, alt. 200–250 m., *Pennell*, no. 3593 (Gr.), fl. light-blue; open loam slope, "La Trinidad," Libano, *Pennell*, no. 3339 (Gr.), fl. bluish-white.
ANTIOQUIA, TOLIMA, and CUNDINAMARCA: common up to 2000 m., *Mayor*, no. 544, acc. to Heering, l. c.
EL VALLE: La Manuelita near Palmira, alt. 1100–1302 m., *Pittier*, no. 804 (Gr.).
WITHOUT LOCALITY: *Otto*, no. 448 (Gr.); *Karsten* (Gr.); *Wagener* (U. S.).
[Southern U. S. to Argent.]

Widely distributed in the warmer parts of America, common and variable. The numerous varieties founded on leaf-contour, pubescence, flower-color, odor, etc., appear to have no more than formal value, since they rest upon arbitrarily selected combinations of characters subject to independent variation. The only variety definitely reported from Colombia is the following, which to a considerable extent bridges the gap between this species and *E. barranguillense*.

Var. **pauciflorum** Hieron. Heads more slender, 10–16-flowered; involucre 1 cm. long, the scales pale, the intermediate and inner ones tending to be acute; corollas pale violet or lilac.— Hieron. in Engl. Bot. Jahrb. xxviii. 564 (1901), as *pauciflora*.

BOLIVAR: Cartagena, *Billberg*, acc. to Hieron. l. c.

MAGDALENA: near Santa Marta, *H. H. Smith*, alt. 153 m., no. 1991 (Gr., U. S.).

[Venezuela, acc. to Hieron. l. c.]

20. **E. corymbosum** Aubl. Erect much branched shrub, 1–3 m. high; stems terete, finely tomentellous, the hairs curved, some of them gland-tipped; leaves opposite, petiolate, deltoid, 1.7–6 cm. long, nearly or quite as broad, obtuse or acute, coarsely crenate-toothed except at the widely and shallowly cordate or subtruncate base, yellow-green, puberulent or smooth above, paler and finely pubescent on the nerves and veins beneath; petiole 1–2 cm. long; heads in dense flattish compound corymbs; scales many-ranked, closely appressed, their 3–5 nerves tending to spread slightly as they reach the green rounded tips.— Guian. ii. 799 (1775). *E. atriplicifolium* Lam. Encyc. ii. 407 (1786); Vahl, Symb. iii. 96 (1794); Hieron. in Engl. Bot. Jahrb. xxviii. 567 (1901); Urb. Symb. Ant. iv. 623 (1911). *E. repandum* Willd. Spec. iii. 1767 (1804); Griseb. Fl. Brit. W. Ind. 358 (1861). *Osmia repanda* (Willd.) Sch. Bip. Pollichia, xxii.–xxiv. 252 (1866).

ANTIOQUIA: near the city so named, alt. 500 m., *Lehmann*, no. 7996, acc. to Hieron. l. c.

[West Indies, from the Bahamas to Guadaloupe; French Guiana, acc. to Aubl.]

No specimens of this species have been seen from the continent, but it is here included on the basis of the Colombian report by Hieronymus, l. c.

Sect. II. SUBIMBRICATA (DC.) Hoffm. Involucre campanulate or turbinate, rarely cylindric, seldom more than twice as long as thick;

scales very unequal, imbricated in 3–several graduated series, persisting until after the fall of the achenes.— Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 140 (1890). *Eupatorium* ser. *Subimbricata* DC. Prod. v. 152 (1836). *Eupatorium* sect. *Heterolepis* Bak. in Mart. Fl. Bras. vi. pt. 2, 301 (1876). *Batschia* Moench, Meth. 567 (1794). *Wikströmia* Spreng. Syst. iii. 434 (1826). *Critonia* DC. Prod. v. 140 (1836). *Disynaphia* DC. Prod. vii. 267 (1838). *Heterolaena* Sch. Bip. ex Benth. & Hook. f. Gen. ii. 245 (1873).— Species very numerous, chiefly perennial herbs or shrubs.

Key to Species.

a. Leaves entire, rusty-woolly beneath . . . . 21. *E. gynoxoides.*
a. Leaves toothed, undulate, or in a few cases (when not rusty-woolly) entire *b.*
  b. Heads few (mostly 5–13)-flowered *c.*
    c. Leaves strongly discolorous, white-lanulate beneath *d.*
      d. Leaf-blade ovate-oblong, obtuse, rounded at base 22. *E. origanoides.*
      d. Leaf-blade deltoid-ovate, acutish, cordate . . . . 23. *E. niveum.*
    c. Leaves (when mature) never whitened beneath *e.*
      e. Leaves spatulate-obovate, very fleshy, 1-nerved; lateral veins (pinnate) very obscure or invisible . . . . 24. *E. sciaphilum.*
      e. Leaves never obovate; lateral veins or nerves clearly evident *f*
        f. Heads separate or in small glomerules loosely disposed in open forking cymose panicles . . . . 25. *E. iresinoides.*
        f. Heads crowded in flattish or moderately convex corymbs or in corymbosely disposed subglobose glomerules *g.*
          g. Leaves pinnately veined, subsessile or very shortly petioled *h.*
            h. Leaves oblong or lanceolate, coriaceous *i.*
              i. Leaves tomentose beneath . . . . 26. *E. salicinum.*
              i. Leaves subglabrous beneath *j.*
                j. Branches of the inflorescence and pedicels subglabrous, often vernicose . . . . 27. *E. baccharoides.*
                j. Branches of the inflorescence and pedicels rusty-pubescent . . . . 28. *E. arbutifolium.*
            h. Leaves ovate, membranaceous 47. *E. turbacense*, v. *ovatifolium.*
          g. Leaves palmately 3(–5)-nerved from or somewhat above the base *k.*
            k. Leaves slender-petioled; lamina suborbicular- to lance-ovate, rounded at base *l.*
              l. Leaves firm-chartaceous, subentire or obscurely serrate, bullate above, tomentose beneath . . . . 29. *E. Stuebelii.*
              l. Leaves subcoriaceous, small (1.5–2.7 cm. long), glabrous above, sparingly hirtellous on

the nerves and principal veins beneath, entire from the base nearly or quite to the middle 30. *E. arcuans.*

l. Leaves membranaceous, conspicuously toothed from much below the middle *m.*

m. Heads pedicelled; leaves large, 5–6.5 cm. wide; petiole about 4 cm. long . . . . 31. *E. Vargasianum.*

m. Heads sessile in glomerules *n.*

n. Hispid-pubescent; teeth of leaves rounded . . . . 32. *E. smilacinum.*

n. Pubescence, when present fine and soft *o.*

o. Leaves suborbicular-ovate, 5–8 cm. wide . . . . 33. *E. acuminatum.*

o. Leaves lance-ovate, 2–4 cm. wide 34. *E. pseudoglomeratum.*

k. Leaves rhombic-ovate or -lanceolate, cuneately decurrent on short petioles or narrowed to a subsessile base . . . . 35. *E. inulaefolium.*

f. Heads in dense ovoid or pyramidal panicles or thyrses *p.*

p. Petioles at least 1 cm. long *q.*

q. Leaves coarsely serrate-dentate; teeth 2–3 mm. high; petioles 2–4 cm. long . . . . 36. *E. morifolium.*

q. Leaves finely serrate; teeth 0.5–0.8 mm. high; petioles 1–1.5 cm. long . . . . 37. *E. thyrsigerum.*

p. Leaves sessile or nearly so . . . . 38. *E. densum.*

b. Heads numerously (20–∝) flowered *r.*

r. Leaves 3(–7)-nerved from or somewhat above the base *s.*

s. Involucral scales 2–3(–5)-ribbed; heads 3–8 mm. high *t.*

t. Leaves lanceolate, small (2–5 mm. wide) . . . . 39. *E. miserum.*

t. Leaves ovate (or in the glandular-pubescent *E. pereziodes* ovate-elliptical), 1 cm. or more wide *u.*

u. Weak annual; heads numerous, small (4 mm. high), separate on filiform pedicels in an open panicle . . . . 40. *E. microstemon.*

u. Perennial herbs or shrubs, never viscid; heads clustered in terminal corymbs or small usually dense cymes, these separate and disposed in a convex corymb *v.*

v. Heads about 25-flowered *w.*

w. Heads 3.5–5.5 mm. high, in rather dense terminal glomerules *x.*

x. Florets rose-colored or purplish; achenes hispid at least on the angles; perennial herb . . . . 41. *E. pycnocephalum.*

x. Florets white; achenes glabrous; rusty-pubescent herb or shrub . . . . 42. *E. Klattianum.*

w. Heads about 7 mm. high, in somewhat looser cymes; florets white . . . . 43. *E. Pennellii.*

v. Heads 35–70-flowered, 7–8 mm. high; florets roseate or lilac; leaves ovate-lanceolate, dull, punctate, drying dark . . . . 44. *E. obscurifolium.*

u. Perennial herb; heads rather few in a lax diffuse panicle; pedicels 1–2 cm. long . . . . 45. *E. perezioides.*

u. Perennial herb or shrub, smoothish, viscid about the nodes and petioles; leaves slightly succulent,

with pellucid veinlets; heads in a thyrsoid panicle; involucral scales acute................46. *E. magdalenense.*
t. Leaves broadly elliptical, glabrous...........59. *E. tinifolium.*
s. Scales multistriate; heads 1 cm. or more high *y.*
y. Leaves membranaceous, coarsely crenate-dentate 85. *E. paezense.*
y. Leaves coriaceous, obscurely serrate..........47. *E. vitalbae.*
r. Leaves pinnately veined *z.*
z. Leaves perfoliate........................48. *E. ornithophorum.*
z. Leaves on winged petioles; these biauriculate at base. 89. *E. nemorosum.*
z. Leaves subsessile, the petiole (wingless) rarely 3 mm. long *aa.*
aa. Involucral scales about 20, substramineous, obtuse 49. *E. turbacense.*
aa. Scales 30–50, narrow, acutish............50. *E. amygdalinum.*
z. Petioles (wingless) about 1 cm. long *bb.*
bb. Heads subsessile in glomerules, these disposed in a divaricately branched panicle; scales about 30, obtuse.................................51. *E. fuliginosum.*
bb. Heads pedicelled, in dense cymose corymbs; scales about 17–18, acute or acutish............52. *E. popayanense.*

21. **E. gynoxoides** Wedd. Stoutish shrub, 1.2–2 m. high; branches thick, rusty-tomentose; leaves petiolate, entire, oblong-lanceolate, thickish, 2.5–6 cm. long, puberulent-tomentellous and at length glabrate and shining above, covered beneath with a thick coating of rusty wool; petiole 2–10 mm. long; heads 15–20, 6–8 mm. long, disposed in a dense corymb the size of a walnut; scales of the campanulate involucre about 15, in about 3 ranks, linear, sharp-pointed; corollas slightly hairy especially toward the top; achenes slightly hispid on the angles; pappus-bristles very unequal.— Chlor. And. i. 216 (1857).

CUNDINAMARCA: cold places of the Prov. of Bogotá, *Goudot,* acc. to Wedd. l. c.

Apparently never rediscovered. The characters, here compiled from Weddell's original diagnosis, are unfortunately insufficient to show the affinities of the plant within the section.

22. **E. origanoides** HBK. Shrub, 1–3 m. high, climbing or leaning, with slender forking or trichotomous branches; branchlets terete, spreading, finely white-woolly; internodes often 1 dm. long or more, much exceeding the ovate-oblong undulate-crenulate leaves; leaf-blade rounded at the tip, rounded or truncate at the base, 2–5 cm. long, 1–1.8 cm. wide, rather firm in texture, finely bullate-rugulose and glabrescent above, white-lanulate and prominently reticulate-veiny beneath; petiole 8–13 mm. long; corymbs terminal on the

branches, subglobose, 2–4 cm. in diameter; heads about 11-flowered, pedicellate; scales of the involucre oblong, stramineo-scarious, rounded at the tip, woolly on the back; corollas white.— Nov. Gen. et Spec. iv. 114 (1820).

"Regno Novo-Granatensi?" *Humboldt & Bonpland*, acc. to Kunth in HBK. l. c.

[Ecuador.]

This species, founded by Kunth on material of Humboldt & Bonpland without precise indication of its source, was by him doubtfully attributed to Colombia. Subsequently rediscovered in Ecuador, it is probably also a native of Colombia although not as yet fully demonstrated in the latter country.

23. **E. niveum** HBK. Shrub 1–2 m. high, in habit very like the preceding, but the leaves (also silvery-white beneath) deltoid-ovate, acute or acutish, more finely and definitely crenate; heads more massed in large compound corymbs (1–2 dm. in diameter); involucre, corollas, etc., as in the preceding.— Nov. Gen. et Spec. iv. 115, t. 342 (1820).

Cauca: near Popayan? *Humboldt & Bonpland*, acc. to Kunth in HBK. l. c.

Nariña: between Meneses and Pasto in the Cordillera Meridianal, alt. about 3000 m., *André* (Gr.).

[Ecuador.]

24. **E. sciaphilum** Robinson. Straggling shrub; stems soft-woody, 2–4 m. long; branches terete, glabrate; branchlets tawny-puberulent; leaves opposite, spatulate-obovate, quite entire, glabrous, thick-coriaceous, sessile or nearly so, 5–8 cm. long, 1.8–3.2 cm. wide, 1-nerved; heads in a loose very convex corymb, about 10-flowered; scales of the cylindrical involucre few (about 9), very unequal, acutish, ciliolate but otherwise smooth; corollas much exserted, dark purplish-violet.— Proc. Am. Acad. liv. 256 (1918).

Antioquia: in light shade, alt. 2292–2350 m., *Kalbreyer*, no. 1445 (K.).

Noteworthy for its fleshy entire leaves and attractive deeply colored flowers. Seemingly promising for horticulture.

25. **E. iresinoides** HBK. Spreading, reclining, or weakly climbing, perennial, quite herbaceous or more or less woody, 0.5–2 m. long, light gray-green, short-velvety at least as to the branchlets and lower surface of the leaves; the latter ovate, narrowed or acuminate to a

mostly obtuse or rounded tip, serrate to undulate or subentire, 4–6 cm. long, 2–3 cm. wide, 3-nerved from above the base; this cuneately decurrent on the petiole; heads about 5-flowered, slender, shortly pedicelled in open forking cymose panicles; involucral scales 11–16, stramineous and subscarious, very unequal, rather loosely imbricated, acute; corollas pale yellowish (Smith); achenes pubescent.— Nov. Gen. et. Spec. iv. 106, t. 340 (1820); Klatt in Engl. Bot. Jahrb. viii. 34 (1887); Heering, Mém. Soc. neuchât, Sci. Nat. v. 419 (1913). *E. iresinoides*, var. *α. villosum* Steetz in Seem. Bot. Herald, 145 (1854); Hieron. in Engl. Bot. Jahrb. xxviii. 573 (1901). *E. celosioides* Willd. ex Steetz, l. c. (invalid name, needlessly published). *E. celtidifolium* Klatt, l. c., not Lam.

MAGDALENA: Las Nubes and Onaca, alt. about 600 m., *H. H. Smith*, no. 503 (Gr., U. S.); lower hills between Rio Frio and S. Andres de la Sierra, alt. about 200 m., *Pittier*, no. 1716 (U. S.).

TOLIMA: at the base of the Andes near Ibagué, *Humboldt & Bonpland*.

HUILA: east of Neiva, *Rusby & Pennell*, no. 1048 (N. Y.); Patico, *Lehmann*, no. 4768 (N. Y.).

EL VALLE: among shrubs on savannahs about Tocotá, alt. 1600 m., *Lehmann*, no. 3430 (Gr.); on stony sterile soil along the Rio Dagua, *Lehmann*, no. 3813 (Gr.); La Paila, *Holton*, no. 320 (Gr., K.).

[Venez., Margarita, St. Vincent, Martinique, Panama. Said by Hemsl. Biol. Cent.-Am. Bot. ii. 96 (1881) to extend southward to Peru.]

Var. *α*. **villosum** Steetz, l. c. Copiously pubescent; leaves softly and conspicuously tomentose beneath.— Synon. and distrib. as above.

Var. *β*. **glabrescens** Steetz. l. c. Finely and often rather inconspicuously pubescent.

MAGDALENA: on rocky hills by the seashore near Plaza Brava, *H. H. Smith*, no. 607 (Gr.).

[Panama, Venez., Trinidad.]

Poorly marked and of merely formal value.

The flowers of this species are sometimes reported on field-labels as yellow. Since, however, really yellow flowers are decidedly rare in the *Eupatorieae* it is not unlikely that they are here nearly or quite white and that the impression of yellow color arises from the stramineous scales, which in this species are considerably more conspicuous than the minute and almost included florets.

26. **E. salicinum** Lam. Shrub; branches somewhat angular, puberulent when young; leaves opposite, subsessile, oblong-lanceolate,

attenuate at both ends, pinnately veined, entire, revolute on the margin, 8–17 cm. long, 1–2 cm. wide, firm in texture, glabrous and rugose above, sordidly tomentose beneath; heads about 10-flowered, in dense convex compound corymbs at length disposed in a more or less pyramidal panicle; scales oblong, obtuse (except the outermost), dorsally pubescent and ciliolate; florets much exserted; achenes beset on ribs and faces with sessile glands.— Encyc. ii. 409 (1786); HBK. Nov. Gen. et Spec. iv. 131 (1820).

"New Grenada": without precise locality, *Triana*, no. 1218 (K.).
[Ecuador and Peru.]

27. **E. baccharoides** HBK. Smooth shrub, the young parts viscid and often vernicose; branches leafy; leaves opposite, lance-oblong, short-petioled, acute at both ends, thickish and rather firm, 6–8 cm. long, 1.7–2.5 cm. wide, pinnately veined, serrulate; corymbs 7–10 cm. in diameter, many-headed, often nodding or pendulous; heads about 7-flowered; scales about 12, lance-oblong, acutish, loosely 3-ranked, commonly glutinous, covered with minute sessile glands and a few inconspicuous hairs; corollas with short gland-dotted proper tube and a much longer smoothish cylindrical throat; achenes beset on the angles with sessile glands.— Nov. Gen. et Spec. iv. 132 (1820); Benth. Pl. Hartw. 199 (1845). *E. bogotense* DC. Prod. v. 181 (1836).

Cauca: near Almaguer, *Humboldt & Bonpland*, no. 2085 (Par., phot. Gr.).
Cundinamarca: Santa Fé de Bogotá, specimen from herb. of Delessert and now in DeCandollean Prod. herb. (phot. Gr.); near Bogotá, *Hartweg*, no. 1100 (N. Y.); *Holton*, no. 309 (N. Y.); Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, no. 87 (Gr.).
Without exact locality: *Purdie* (Gr.).

A species striking on account of its curved or actually inverted inflorescences. Whether this trait is constant or holds good only at certain stages of development or under particular conditions cannot be satisfactorily determined from the scanty material as yet available.

28. **E. arbutifolium** Benth. Shrub 9–12 dm. high, with round smooth leafy branches; leaves smooth and leathery, opposite, lance-oblong, at each end narrowed to an obtuse termination, inconspicuously serrulate (the teeth minute, cuspidate, 2–3.5 mm. apart), coriaceous, 5–7.5 cm. long, 1.5–2 cm. wide, glabrous, pinnately veined; heads

6–7-flowered, in dense round-topped rusty-hirtous corymbs (about 8 cm. in diameter); scales about 3-ranked, oblong, obtuse; achenes with ciliate ribs.— Pl. Hartw. 199 (1845).

CAUCA: in woods near Huambia, Prov. Popayan, *Hartweg*, no. 1100 (K., phot. Gr.).

A species as yet known only from the original collection.

29. **E. Stuebelii** Hieron. Shrubby; branches arcuate, terete, sordid-tomentose; internodes 5–10 cm. long; leaves opposite, petiolate ovate, acuminate, rounded or subcordate at base, rather inconspicuously and remotely serrulate, above deeply rugose-bullate, nearly glabrous and shining; below tawny-tomentose, 4–6 cm. long, 3–4 cm. wide, 3-ribbed from the base, supplementary nerves arising near the origin of the lateral ones; ribs connected by irregular transverse veins; petiole slender, 1–2 cm. long, tomentose; corymbs compact, trichotomous, tomentose; heads 10-flowered, subsessile or shortly pedicelled; involucre cylindrical; the scales 4–5-seriate, 2–3-ribbed, obtuse or acutish, mostly purple toward the tip; corollas lilac; achenes slightly hispidulous on the angles toward the summit.— Hieron. in Engl. Bot. Jahrb. xxi. 329 (1895).

BOYACÁ: Páramo de Coper, *Stübel*, no. 164 (Berl., phot. and fragm. Gr.). [Ecuador.]

Said to have terete branches and campanulate-cylindric involucres, and to belong to § *Subimbricata*, yet in many respects suspiciously similar to *E. columbianum* of § *Cylindrocephala*, a species in which the branches are rather conspicuously grooved.

30. **E. arcuans** Robinson. Shrub with terete very flexuous glabrate branches and arcuate angled rusty-tomentose very leafy branchlets; leaves small (1.5–3 cm. long, 1–1.5 cm. broad), opposite, petiolate, ovate, subacuminate, rounded to an acutish base, serrately 2–3-toothed on each side above the middle, thick-membranaceous, conspicuously 3-ribbed from the base, subglabrous and with nerves depressed above, olive-green and essentially glabrous beneath except on the prominulent sparingly pubescent nerves; petiole slender, about 5 mm. long; heads 7 mm. long, about 10-flowered; involucre subcylindrical; scales about 16, very unequal, in about 3 loosely imbricated ranks, oblong, obtuse or rounded at the tip, 3–5-ribbed, glabrous except for an obscure ciliolation; corolla glabrous, 4 mm. long, with the proper tube 2.4 mm. in length and a somewhat ampliated

throat about half as long; achenes glabrous, 2.5 mm. long.— Proc. Am. Acad. liv. 237 (1918).

"New Grenada": without more exact locality, *Triana*, no. 1191 (K., phot. Gr.).

31. **E. Vargasianum** DC. Shrub with terete ascending branches clothed with dense sordid tomentum of purplish-brown jointed hairs; leaves opposite, ovate-oblong, acute to acuminate, crenate-serrate, shallowly cordate or more often rounded at base, 7–20 cm. long, 5–12 cm. wide, above closely beset with somewhat swollen persistent bases of small hairs and with subsessile glands, below gray-tomentose, 3-nerved from a point decidedly above the base (2–4 pairs of minor veins pinnately arranged between the actual base and the origin of the main lateral nerves); petiole 1.4–3.7 cm. long, thick, densely tomentose; corymbs terminal, dense, trichotomous, many-headed; heads about 10-flowered, on short thick hirsute pedicels; scales about 3-ranked, stramineous, more or less stained with claret color, oblong-lanceolate, thin, subscarious, 3–5-nerved, merely acutish to subattenuate, smooth on the back; achenes grayish or yellowish-brown, studded with sessile glands.— Prod. v. 155 (1836); Klatt in Engl. Bot. Jahrb. viii. 36 (1887); Heering, Mém. Soc. neuchât. Sci. Nat. v. 420 (1913).

Cauca: in open woods on mountain slopes near Popayan, *Lehmann*, no. 938, acc. to Klatt, l. c.
Antioquia: in central Andes on a hill above America near Medellin, alt. 1700 m., *Mayor*, no. 392, acc. to Heering, l. c.
[Venezuela.]

No material from Colombia has been seen by the writer. The species, however, appears to be frequent and somewhat widely distributed in Venezuela, from Caracas to Tovar.

32. **E. smilacinum** HBK. Twining herb with furrowed and ribbed stem and hispid-pubescent widely spreading almost divaricate branches; leaves opposite, petiolate, ovate, entire at the acute to acuminate apex and abruptly narrowed to a rounded base, elsewhere coarsely crenate-serrate, 3-nerved from the base, membranaceous, hispidulous on the nerves and veins above, hispid beneath, about 5 cm. long, 2–2.4 cm. wide; heads sessile in spherical glomerules, these disposed in a divaricately branched corymb or panicle; involucre short-cylindric; scales oblong, green, striate, ciliated.— Nov. Gen.

et Spec. iv. 111 (1820); DC. Prod. v. 144 (1836). *Osmia smilacina* (HBK.) Sch. Bip. Pollichia, xxii.-xxiv. 252 (1866).

TOLIMA? on the Quindio Mountains near Alto de Guayaval and Quebrado de Toche? acc. to Kunth in HBK. l. c.

A species never rediscovered and known only from the original immature specimen secured without certain record of locality by Humboldt & Bonpland. The type is in the Museum of Natural History at Paris and a (rather poor) photograph of it, taken by the writer in 1905, is now in the Gray Herbarium. From this it has been possible to check and verify most of the characters of the original description, and to make reasonably sure that the species is distinct from any other known in Colombia. On the other hand, the precise position in the genus is still doubtful. DeCandolle (whose knowledge of the *Compositae* of Humboldt & Bonpland has in several other cases proved defective or erroneous) places this species in § *Cylindrocephala,* but Kunth, who certainly must have had access to the original material, grouped it with species of § *Subimbricata,* where for the present it seems best to give it provisional location.

33. **E. acuminatum** HBK. Branched perennial herb or soft- and pithy-wooded shrub, 2–4 m. high; stems hexagonal, smooth, pale green to straw-colored or at length brownish; leaves opposite, slender-petioled, ovate, acuminate, sharply or sometimes bluntly serrate-dentate, rounded or shallowly cordate at the broad and often unsymmetrical base, 5–7-nerved, thin, light-green, often and in varying degree pellucid-veined, 8–15 cm. long, 6–8 cm. wide, obscurely puberulent at least on the nerves beneath; heads 6–7-flowered, slender, sessile in subglobose glomerules disposed in convex corymbs; involucre cylindrical, 5.5 mm. long; scales about 14, delicate, stramineous, oblong, rounded at the tip; corollas slender-tubular, light violet-blue (Lehmann) or occasionally whitish (André), fragrant; achenes 2 mm. long, with black hispid faces and lighter glabrous ribs.— Nov. Gen. et Spec. iv. 107 (1820); Klatt in Engl. Bot. Jahrb. viii. 33 (1887). *E. pellucidum* HBK. l. c. 108 (1920). *E. tolimense* Hieron. in Engl. Bot. Jahrb. xix. 45 (1894), see Robinson, Proc. Am. Acad. xlii. 46 (1906).

ANTIOQUIA: *Jervise* (K.).

CUNDINAMARCA: at Fusagasuga near Bogotá, alt. 1800 m., *André,* no. 1333 (Gr.).

TOLIMA: in densely bushy places near Dolores, alt. 1400–1800 m., *Lehmann,* no. 7487 (Berl., fragm. Gr.); in field loam, "La Trinidad," Libano, alt. 1000–1200 m., *Pennell,* no. 3357 (Gr.).

HUILA: Neiva, *Rusby & Pennell*, no. 658 (N. Y.).

EL VALLE: in shady places near Buga, alt. 900 m., *Lehmann*, no. 796 (Gr.); shrubby spots of savannahs near Tocotá, alt. 1600 m., *Lehmann*, no. 3429 (Gr.).

CAUCA: forests in highlands of Popayan, alt. 1300–2000 m., *Lehmann*, no. B. T. 598 (Gr.); in densely shrubby places of the high plains about Popayan, alt. 1600–2000 m., *Lehmann*, no. 6081, acc. to Hieron. l. c. xxviii. 572 (1901).

WITHOUT LOCALITY: *Triana*, no. 1180 (K., N. Y.); *Linden*, no. 861 (K.).

34. **E. pseudoglomeratum** Hieron. Perennial, herbaceous or somewhat woody, 1 m. high; stems several, erect, terete, leafy, when young finely sordid-pubescent; leaves opposite, short-petioled, ovate-lanceolate, attenuate-acuminate, sharply serrate at the sides, entire toward the rounded or somewhat cuneate base, 3-nerved, glabrous or early glabrate and with depressed nerves above, below pubescent on the nerves, 2.5–6.5 cm. long, half as wide, firm-membranaceous, drying dark; heads 6–7-flowered, sessile or nearly so in spherical glomerules corymbosely disposed at the ends of the branches; scales about 12, glabrous, stramineous, pale toward the base, brownish toward the acute or acutish tip, imbricated in about 3 series, mostly 4-ribbed and 5-nerved; corollas glabrous.— Hieron. in Engl. Bot. Jahrb. xxix. 8 (1900).

WITHOUT PRECISE LOCALITY: merely from "Nouvelle Grenade," *Triana*, no. 16 (Gr.).

[Ecuador.]

35. **E. inulaefolium** HBK. Tall erect sparingly branched pale grayish-green shrub sometimes attaining 4 m. in height; stem when young and lower surface of the leaves densely tomentose; branches terete or obscurely hexagonal, velvety (tomentum often yellowish or even tawny in dried material); leaves opposite, rhombic-ovate to oblong-lanceolate, caudate-attenuate at the entire apex, cuneate at the also entire but more abruptly narrowed short-petioled or subsessile base, coarsely few-toothed to finely crenate or subentire on the lateral margins, above grayish-puberulent, below canescent-velvety, 1 dm. long, 2–4 cm. wide, thick-membranaceous, 3-nerved well above the base; heads 8–14-flowered, in terminal usually large flattish or convex compound corymbs, subsessile; scales about 12, oval to narrowly oblong, rounded at the tip, stramineous, the inner nearly or quite smooth, the outer somewhat velvety on the back; florets pure white (Smith, Pennell) or ochroleucous or erubescent (Langlassé), often very

fragrant; achenes from nearly smooth to finely and upwardly ciliolate on the ribs and (microscopically) glandular-punctate on the faces.— Nov. Gen. et Spec. iv. 109 (1820); Hieron. in Engl. Bot. Jahrb. xxii. 765 (1897), where synonymy is considerably extended. *E. molle* HBK. l. c. *E. pallescens*, var. *hirsutum* DC. Prod. v. 154 (1836); Bak. in Mart. Fl. Bras. vi. pt. 2, 325 (1876), as *hirsuta*. *E. cinereum* Griseb. Fl. Brit. W. Ind. 359 (1861). *E. decemflorum* Klatt in Engl. Bot. Jahrb. viii. 34 (1887), not DC. *E. inulifolium* Heering, Mém. Soc. neuchât. Sci. Nat. v. 419 (1913).

TOLIMA: near Mariquita, alt. 850 m., *Humboldt & Bonpland* (Par., phot. Gr.).

CAUCA: in light thickets about Inzá, alt. 1200–2000 m., *Lehmann*, no. 2185, (Gr.); in open woods near Popayan, alt. 2500–3000 m., *Lehmann*, no. 897 (Gr., U. S.), being the number which by clerical or typographical error was cited by Klatt, l. c., as 98.

CUNDINAMARCA: slopes of Montserrate above Bogotá, alt. 2900 m., *Mayor*, no. 70, acc. to Heering, l. c.

MAGDALENA: common on campo, Jiracasaca near Santa Marta, alt. 762 m., *H. H. Smith*, no. 326 (Gr., U. S.); clearing, edge of forest, alt. 1370 m., *H. H. Smith*, no. 624 (Gr.).

CORDILLERA OCCIDENTAL: in clayey soil, *Langlassé*, no. 53 (Gr.).

[Southern Antilles to Venezuela and Argentina.]

A characteristic species of wide range and easily recognized when taken in a broad and natural sense, but varying considerably in the amount and persistence of the pubescence, in the density of the inflorescence, and in the dentation of the leaves. The following forms are often, but not always, distinguishable:

Forma **typicum.** Leaves densely and permanently canescent-tomentose beneath, the reticulation of the veins being so covered as to be obscure or invisible. (Synonymy and exsiccatae as above.)

Forma **suaveolens** (HBK.) Hieron. Leaves somewhat harsher, above more bullate, beneath at least in age thinly tomentose or merely soft-pubescent, the reticulated veins clearly evident.— Hieron. in Engl. Bot. Jahrb. xxix. 11 (1900), xxviii. 572 (1901). *E. suaveolens* HBK. Nov. Gen. et Spec. iv. 109 (1820).

TOLIMA: in temperate regions of the mountains near Santa Ana, Mariquita, and Ibagué, alt. 730–1280 m., *Humboldt & Bonpland* (Par., phot. Gr.); clearing, in loam, Libano, alt. 1100–1400 m., *Pennell*, no. 3236 (Gr.).

HUILA: Eastern Cordillera near Neiva, *Rusby & Pennell*, no. 498 (N. Y.), "fls. yellow"; nos. 497 (N. Y.) and 1055 (N. Y.), "fls. white."

CAUCA: in woods of the plateau near Popayan, alt. 1500–2000 m., *Lehmann*, no. 5541, acc. to Hieron. l. c.; on savannahs and in thickets about Inzá, alt. 1000–1700 m., *Lehmann*, no. 7994, acc. to Hieron., l. c.

META: in loam east of Villavicencio, alt. 450–500 m., *Pennell*, no. 1595 (Gr.).

[Venezuela.]

36. **E. morifolium** Mill. Large shrub or even small tree; branches thick, green, angulate-ribbed, pithy or often fistulose, when young slightly woolly, soon nearly or quite glabrate; leaves opposite, large, broadly ovate to ovate-oblong, coarsely serrate (teeth 1–2 mm. high, 4–8 mm. wide at base), mostly short-acuminate at the tip, rounded to an entire usually obtuse, rarely acute or sometimes cordate base, 12–20 cm. long, 8–13 cm. wide, firm-membranaceous or somewhat thick-chartaceous, green on both sides, 3-ribbed above the base (in other cases almost regularly pinnate-veined), pellucid-punctate; the smaller veins light-colored and slightly prominulent beneath; heads (4–)8–12-flowered, subsessile to shortly pedicellate, in large dense terminal leafy-bracted thyrsoid panicles; involucral scales stramineous, ovate, obtuse or rounded at the apex, smoothish or arachnoid-woolly, about 5-ranked; corollas (greenish to yellowish-white) tubular, 4 mm. long, slightly constricted just below the limb; teeth lance-oblong; achenes 2 mm. long, dark-olive to nearly black, with narrow lighter-colored ribs.— Dict. ed. 8, no. 10 (1768); Robinson, Proc. Am. Acad. xlii. 42 (1906). *E. populifolium* HBK. Nov. Gen. et Spec. iv. 111 (1820). *E. critonioides* Steetz in Seem. Bot. Herald, 145 (1854). *E. megaphyllum* Bak. in Mart. Fl. Bras. vi. pt. 2, 322 (1876); Hieron. in Engl. Bot. Jahrb. xxviii. 569 (1901).

MAGDALENA: near Santa Marta on road to Onaca, alt. 305 m., *H. H. Smith*, no. 669 (Gr., U. S.).

EL VALLE: La Paila, *Holton*, no. 317 (N. Y.); in dense thickets near Las Juntas del Dagua, alt. 2000–2800 m., *Lehmann*, no. 7697, acc. to Hieron. l. c. as *E. megaphyllum*.

WITHOUT LOCALITY: *Triana*, no. 1181 (N. Y.).

[Mexico to Brazil.]

A coarse species of wide range, originally described from Vera Cruz, passing without easy demarcation into several forms differing in leaf-contour, number of florets, and greater or less pubescence on the inflorescence. Abundant material is now available from Mexico and Central America, but it does not fall into satisfactory varieties.

37. **E. thyrsigerum** Hieron. Soft-woody shrub with liana-like terete striate stems sometimes 5 m. in length; leaves opposite, ovate, 12 cm. or more long, 5 cm. or more wide, acute or somewhat attenuate

at the tip, rounded at the base, firm-membranaceous or somewhat chartaceous, pinnately veined and finely reticulated, shallowly serrate (the teeth about 0.5 mm. high, 3–5 mm. wide at base), glabrous or nearly so above, covered beneath with a sparse tawny or gray arachnoid pubescence; petioles 1–1.5 cm. long, slender; heads about 10-flowered, on short pedicels, disposed in dense thyrse-like panicles; involucre narrowly campanulate to subcylindric, pale, stramineous; scales 3–5-ranked, narrowed to a mostly obtuse apex, 3–5-striate; florets fragrant, greenish- or bluish-white (Lehmann).— Hieron. in Engl. Bot. Jahrb. xxviii. 570 (1901).

HUILA: in bushy places of the mountain savannahs, alt. 1000–1500 m., La Plata, *Lehmann*, no. 8445 (Berl., fragm. and phot. Gr.).

When known from more copious material this species may perhaps be found to pass into the preceding, but thus far it appears fairly marked.

38. **E. densum** Benth. Erect smooth shrub, 2 m. high, with round ascending branches; leaves opposite, sessile, oblong- or ovate-lanceolate, caudate-attenuate, 7–10 cm. long, 2–2.4 cm. wide, horizontally spreading or deflexed, serrate from somewhat below the middle, entire at the rounded base, pinnately veined; veinlets pellucid; panicle trichotomously branched, pyramidal, 1.5 dm. in diameter; heads scarcely 5 mm. high, 5–8-flowered, sessile and closely packed in often subspherical glomerules; involucral scales few-ranked, scarious-margined, ciliate, the inner narrowly oblong, the outer progressively shorter, ovate; corolla with scarcely differentiated proper tube; achenes glabrous.— Pl. Hartw. 200 (1845).

CUNDINAMARCA: Cordillera de los Andes near Bogotá, *Hartweg*, no. 1105 (K., phot. Gr.).

Known only from the original collection, but to be easily recognized by its dense paniculate inflorescence and sessile round-based very sharp-pointed leaves.

39. **E. miserum** Robinson. Slender erect inconspicuous perennial, 2–2.5 dm. high; root of slender tough fibres; stems 1–3, terete, about 1 mm. in diameter, obscurely tawny-tomentellous, simple to the paniculately branched leafy-bracted rather few-headed inflorescence; leaves opposite, lanceolate, attenuate to an obtusish tip, crenate except at the narrowly cuneate entire base, membranaceous, green and somewhat puberulent on both surfaces, 3-nerved essentially from the base, 1–2 cm. long, 2–5 mm. wide; petiole 2–3 mm. long;

panicle diffuse, its lower branches opposite and upper mostly alternate, very slender; pedicels filiform, 1–9 mm. long; heads 4.5 mm. high, about 25-flowered, 3.5 mm. in diameter; involucre turbinate-campanulate, persistent and at length reflexed; scales lanceolate to lance-linear, thin, green, the inner subequal, glabrous, a few of the outer considerably smaller, successively graduated, and more or less puberulent dorsally; receptacle small, flat; corollas lilac-tinged or pinkish, 2 mm. long; the proper tube 0.5 mm. long, much exceeded by the distinctly enlarged subcylindric throat; limb externally hispidulous; achenes (immature) pubescent, at least on the angles.— Proc. Am. Acad. liv. 253 (1918).

INTENDENCIA DEL CHOCO: Falls of Truandó, *Schott*, nos. 2 (Field Mus., phot. Gr.), 1 (Field Mus., phot. Gr.).

A delicate species with habit of the Costa-Rican *E. sideritidis* Benth. but more slender, with leaves more pubescent, only half as long, and crenate instead of incisely serrate. The related *E. Sinclairi* Benth of Costa Rica and Panama has broadly ovate leaves with relatively longer petioles. The Ecuadorian *E. lloense* Hieron., of somewhat similar habit and inflorescence, has longer but much fewer-flowered heads, larger leaves, etc.

40. **E. microstemon** Cass. Annual, erect, weak and slender, 1.5–7 dm. high, puberulent; stem soft, terete, often flexuous; leaves opposite (except sometimes the uppermost), deltoid-ovate, 2.5–7 cm. long, 2–5.5 cm. wide, somewhat acuminately narrowed to a mostly obtuse tip, crenate-serrate except at the subtruncate base, thin, green on both surfaces, scarcely paler beneath; heads about 4 mm. high, loosely paniculate; pedicels filiform; involucre campanulate; scales thin, about 3–4-seriate, with mostly 2 pale ribs and 3 green nerves; the outer scales lanceolate, acute, the inner linear-oblong, rounded at the somewhat scareous tip; corollas white or (in the formal var. LILACINUM Ktze.) lilac.— Dict. xxv. 432 (1822); Ktze. Rev. Gen. i. 338 (1891). *E. paniculatum* Schrad. Comm. Gott. vi. 130 (1827). *E. Berterianum* (Spreng.) Colla, Mem. Acad. Taur. xxxiii. 130, t. 8 (1929). *E. urticifolium* Banks ex Griseb. Fl. Brit. W. Ind. 362 (1861). "*Eriopappus paniculatus* Bess. Cat. Sem. Hort. Volh. a. 1819" and "*Ageratum paniculatum* Hornem. Cat. Sem. Hort. Hafn. a. 1822" acc. to Schrad. l. c. (1827). *Mikania Berteriana* Spreng. Syst. iii. 423 (1826). *E. guadalupense* DC. Prod. v. 170 (1836); Hieron. in Engl. Bot. Jahrb. xxviii. 573 (1901), excl. syn. *E. Sinclairii*; Heering, Mém. Soc. neuchât. Sci. Nat. v. 418 (1913); not Spreng., see Urb. Symb. Ant. iv. 625 (1910).

INTENDENCIA DEL CHOCO: mouth of the Nercua, *Schott*, no. 4 (Field Mus.).

ANTIOQUIA: roadsides at Guaca, alt. 1480 m., *Mayor*, no. 576, acc. to Heering, l. c.

MAGDALENA: a common weed at several points near Santa Marta, alt. 150 m., *H. H. Smith*, no. 522 (Gr., U. S.).

TOLIMA: river-gorge below Nalagaima, *Rusby & Pennell*, no. 1167 (N. Y.) field loam, "La Trinidad," Libano, *Pennell*, no. 3372 (Gr.).

EL VALLE, La Paila, *Holton*, no. 319 (N. Y.); near Calí, alt. 300–1000 m., *Lehmann*, no. 7700, acc. to Hieron. l. c.

[Mex. to Boliv., Venez., Lesser Antil., Porto Rico., and Jam.]

A common and weedlike plant of wide distribution in the warmer parts of America. The nearly related but distinct *E. Sinclairi* Benth. of Panama and Central America may well occur in the northern parts of Colombia. It is more delicate and has an involucre more turbinate at the base, the very small and sharply pointed outermost scales being inclined to extend down upon the summit of the almost capillary pedicel.

41. **E. pycnocephalum** Less. Herbaceous perennial, 4–8 dm. or more high, finely pubescent, the hairs incurved; internodes, especially the upper cauline, elongated (6–12 cm. in length); leaves opposite, slender-petioled, deltoid-ovate, acuminate, crenate-serrate except at the abruptly cuneate or more often truncate or sometimes shallowly cordate base, 3.5–6 cm. long, 2–5 cm. wide, green and at least sparingly pubescent on both surfaces, 3-nerved from the base, the lateral nerves sometimes again forking almost from the start; inflorescence with spreading or ascending branches each bearing a terminal subglobose glomerule of 7–20 or more short-pedicelled heads; these about 25-flowered, 3–5 mm. high; involucre campanulate; scales about 3-ranked, the inner oblong, scarious-margined, obtuse or rounded at the tip, mostly with 3 green nerves and 2 pale ribs united at base in a more or less conspicuous callosity, the intermediate and outer gradually shorter oval and obtuse to rather narrowly lanceolate and decidedly acute, nearly smooth to conspicuously pubescent; florets normally roseate or purplish; achenes black with lighter ribs, somewhat pubescent at least on the ribs.— Linnaea, vi. 404 (1831); Heering, Mém. Soc. neuchât. Sci. Nat. v. 419 (1913). *E. Schiedeanum* Schrad. Ind. Sem. Hort. Goett. 1832, p. 3 (1832); Heering, l. c. *E. Schiedeanum*, var. *virgatum* (Schrad.) DC. Prod. v. 159 (1836); Hieron. in Engl. Bot. Jahrb. xix. 45 (1894).

MAGDALENA: near Santa Marta, alt. 762 m., *H. H. Smith*, no. 623 (Gr.), distrib. as *Ageratum mexicanum*.

HUILA: Cordillera Oriental, east of Neiva, *Rusby & Pennell*, no. 1049 (N. Y.).

ANTIOQUIA: Cordillera Central, near Medellin, alt. 1600 m., *Mayor*, no. 577 acc. to Heering, l. c., as *E. Schiedeanum.*

CUNDINAMARCA: in thickets near Pacho, alt. 1600–2200 m., *Lehmann*, no. 7496 (N. Y.); Cordillera Oriental, above Bogotá, alt. 2500 m., *Mayor*, no. 54, acc. to Heering, l. c.

WITHOUT LOCALITY: *Triana*, nos. 1183 (K.) and 1189 (K.).

[Southwestern U. S., Mex., Cent.-Am., Venezuela.]

Common and weed-like, with the habit of *Ageratum*. Fairly constant in inflorescence and floral character, but through considerable and apparently independent variation of several features (notably the shape, texture, and pubescence of the outer scales of the involucre) passing into many preceptibly different yet not readily delimitable forms not as yet correlated with habitat or range. The early attempts by Schrader and by DeCandolle to divide the plant specifically or varietally appear on examination of the material now available to break down entirely. It is unaccountable that a plant so common and widely distributed in the warmer parts of America should have so completely escaped the notice of the earlier collectors including Humboldt & Bonpland.

42. **E. Klattianum** Hieron. A soft-woody shrub with weak ascending or drooping rusty-pubescent branches; leaves subopposite, deltoid-ovate, cordate, membranaceous, crenate-serrate, 3 cm. long, nearly as wide, acuminate, puberulent above, rusty- or sordid-pubescent beneath; petiole (of the upper cauline leaves) about 1 cm. long; inflorescence and heads as in the preceding; florets greenish-white and fragrant (Lehmann); achenes entirely glabrous.— Hieron. in Engl. Bot. Jahrb. xxviii. 573 (1901). *E. umbrosum* Klatt in Engl. Bot. Jahrb. viii. 35 (1887), not Benth.

CUNDINAMARCA: in open woods about Pasca, alt. 2000 m., *Lehmann*, no. 2520 (Gr.).

Notwithstanding its reported shrubby character, white florets, and glabrous achenes, this species corresponds so closely in many minor features with the preceding as to suggest at least very recent common origin if not varietal relationship.

43. **E. Pennellii** Robinson. Erect perennial herb, 1.5 m. high, nigrescent in drying; stem terete, entirely glabrate at maturity, purple, its internodes 1–1.5 dm. long; leaves opposite, slender-petioled, ovate, long-acuminate, rounded at the base, rather finely serrate (teeth 14–18 on each side, 0.7 mm. high, 1.5–2.5 mm. broad),

mostly 5-nerved from the base, membranaceous, 5 cm. long, 3.5 cm. wide, above sparingly pubescent on the nerves, below nearly or quite glabrous; petiole 1–1.5 cm. long; heads 7 mm. high, about 25-flowered, in small rather loose 4–7-headed cymes disposed in a very open terminal leafy-bracted panicle; pedicels puberulent, 3–6 mm. long; involucre smoothish, campanulate, stramineo-scarious; scales 3–4-ranked, usually 2-ribbed (ribs uniting in a callosity at base); the inner scales elliptic-oblong, with scarious erose mostly rounded tip; the outer progressively shorter, ovate, ciliate and somewhat pubescent on the back; corollas white; achenes 2 mm. long, short-pubescent, dark with lighter ribs.— Proc. Am. Acad. liv. 254 (1918).

HUILA: foot of Cordillera Oriental, near Neiva, *Rusby & Pennell*, no. 626 (Gr., N. Y.).

A species near the variable *E. pycnocephalum* but with more open cymes, slightly larger heads, white florets, and almost caudate-acuminate many-toothed leaves somewhat nigrescent in drying.

44. **E. obscurifolium** Hieron. Perennial, herbaceous, 2 m. high, branched above, minutely incurved-puberulent, the hairs rusty-brown or purplish; internodes long; leaves opposite, petiolate, lance-ovate, acuminate, rounded at base, serrate, dull, punctate, nigrescent in drying, 4–6 cm. long, 3–3.5 cm. wide; heads 35–70-flowered, in a convex trichotomous cymose corymb (1–1.5 dm. in diameter); pedicels 5–10 mm. long; involucre campanulate; scales narrow, linear-oblong, acutish, all (even the outer) with a long callosity at the base; florets reddish-lilac.— Hieron. in Engl. Bot. Jahrb. xxix. 9 (1900); Heering, Mém. Soc. neuchât. Sci. Nat. v. 420 (1913).

CUNDINAMARCA: above Ubaqué, between the village and the Páramo Cruz Verde, about 2500 m., *Mayor*, no. 53, acc. to Heering, l. c.; slope of Montserrate, above Bogotá and Páramo Cruz Verde, alt. 2700–3200 m., *Mayor*, no. 76, acc. to Heering, l. c.

[Ecuador.]

No Colombian material of this has been seen by the writer. The character is here drawn from the Ecuadorian type, of which there are now a fragment and photograph in the Gray Herbarium.

45. **E. perezioides** Robinson. Slender erect perennial 4–5 dm. high; stem terete, simple to the inflorescence, fuscous-tomentose and glandular; lower internodes very short (2–12 mm. in length), the upper 2–3 cm. long; leaves opposite, ovate-elliptical or oval, obtuse, cordate, crenate-serrate, firm, subcoriaceous, dark-green and sprinkled

with sessile or short-stipitate glands above, much paler, gray-tomentose, and glandular beneath, 4–7 cm. long, 2.5–4 cm. wide, prominulent-reticulate on both surfaces; petioles 2–3 mm. long, fuscous-tomentose; panicle very diffuse, 12–30-headed, the branches opposite, divaricate, long, flexuous, almost filiform; pedicels 1–2.5 cm. long; heads about 36-flowered, about 8 mm. high, 5 mm. in diameter; involucre campanulate, 3–4-seriate; scales purplish-brown, about 3-nerved, the outer short, broadly ovate, obtuse, the inner progressively longer, narrower, and more acute; corollas pale greenish-yellow, tinged with dark purple at the limb; achenes 2 mm. long, dark reddish-brown, upwardly hispid on the angles.— Proc. Am. Acad. liv. 255 (1918).

META: woodland, "Buenavista," west of Villavicencio, alt. 1000–1200 m., *Pennell*, no. 1678 (Gr.).

46. **E. magdalenense** Robinson. Perennial herb, erect or straggling, 3–9 dm. high; branches brown, often obscurely hexagonal, soon glabrate and very smooth; branchlets in the inflorescence somewhat beset with very fine incurved hairs; leaves opposite or the rameal alternate, narrowly ovate, attenuate-acuminate, rounded at base, sharply serrate, thickish-membranaceous as if slightly succulent, green and glabrous on both surfaces, 4–4.5 cm. long, 2–2.5 cm. wide, 3(–7)-ribbed from the base, the reticulated veinlets translucent; petiole 8–14 mm. long; primary branches of the inflorescence wide-spreading, curved-ascending, each bearing several (3–7) short and subequal spreading branchlets (1–3 cm. in length); these 2–3-leaved and floriferous toward the tip, bearing 5–20 heads, the clusters about 2 cm. in diameter; heads pedicelled, 25-flowered; involucre campanulate, 5 mm. high and thick; scales lanceolate, acute, minutely ciliolate, about 3-ranked, subherbaceous, becoming brownish in age, very persistent; corollas white; achenes 1.7 mm. long, black, the lighter-colored ribs remotely and microscopically hispidulous.— Proc. Am. Acad. liv. 250 (1918).

MAGDALENA: moderately common on open ridges, Sierra del Libano, alt. 1677–1982 m., near Santa Marta, *H. H. Smith*, no. 1993 (Gr., Mo.).

Marked by the short and uniform secondary branches of the inflorescence.

47. **E. vitalbae** DC. Vigorous somewhat climbing shrub, with stems often 6–8 m. or more in length; branches, petioles, and inflorescence finely pubescent; leaves opposite, petiolate, leathery,

elliptic-ovate or ovate-lanceolate, acuminate, mostly round-based, 3–5-nerved, shallowly and remotely serrate; panicles ample, 2–3 dm. or more in diameter; heads 45–70-flowered, separate, 12 mm. high, nearly as thick; pedicels 3–25 mm. long; outer scales of the involucre broadly ovate-oblong, acute, many-striate, the inner narrowly lance-oblong; corollas roseate or lilac, 7 mm. long, slightly enlarged near the limb, glabrous; achenes 3 mm. long, glabrous (DC.) or at least microscopically hispid on the angles; receptacle slightly concave.— Prod. v. 163 (1836); Hieron. in Engl. Bot. Jahrb. xxviii. 572 (1901). *E. ecuadorae* Klatt, Ann. k. k. Natur. Hofmus. Wien, ix. 356 (1894). *Campuloclinium surinamense* Miq. Linnaea, xvii. 69, (1843), & Stirp. Surinam. 182, t. 53 (1850).

MAGDALENA: open damp places in forest, generally near streams, Aqua Dulce near Santa Marta, alt. 305 m., *H. H. Smith*, no. 920 (Gr., U. S.).

CAUCA: near Tuquerres, alt. 1400–1800 m., *Lehmann*, no. 5208, acc. to Hieron., l. c.

[Central America to Peru and Brazil.]

Leaves, according to a note of Lehmann, quoted by Hieronymus, l. c., pale, yellowish-green.

48. **E. ornithophorum** Robinson. Perennial herb, grayish-green, tomentellous; stem striate-angulate, gray-brown; leaves lanceolate, caudate-acuminate, pinnate-veined, bluntly and irregularly toothed, bullate and scabrid above, paler and gray-tomentose beneath, 1 dm. long, 2.5–3.5 cm. wide, toward the base at first contracted then expanded into a suborbicular toothed perfoliate disk about 1.2–2 cm. in radius; heads about 22-flowered, 7 mm. high, subsessile in glomerules disposed in a large open terminal cymosely branched panicle; receptacle flat; involucre turbinate, about 4-ranked; scales lanceolate to (the innermost) linear, acute; corollas 3 mm. long, purplish or violet; achenes 1.2 mm. long, coarsely granular on the faces.— Proc. Am. Acad. liv. 254 (1918).

HUILA: Cordillera Oriental, east of Neiva, 7 Aug. 1917, *Rusby & Pennell*, no. 1034 (N. Y., fragm. and phot. Gr.); foot of Cordillera Oriental, near Neiva, *Rusby & Pennell*, no. 479 (N. Y., fragm. Gr.).

Noteworthy on account of the perfoliate leaves, a feature not found in any other Colombian species of the genus as yet recorded. The name has been suggested by a perceptible resemblance of the pairs of connate leaves to birds with wings extended in flight.

49. **E. turbacense** Hieron. Perennial herb, slightly woody at

base, 2 m. high; branches round or nearly so, tawny-pubescent; leaves opposite, nearly sessile, lanceolate, membranaceous, green and glabrous above, scarcely paler and rusty-pubescent on the midrib and chief veins beneath, attenuate to each end, remotely cuspidate-denticulate, 13–15 cm. long, 5–6 cm. wide; panicle rusty-pubescent, open; heads 25–28-flowered, about 5 mm. high, some sessile but mostly pedicelled; involucre campanulate; scales ovate-oblong, 3–4-ranked, mostly 3–4-ribbed toward the base, somewhat silky-pubescent dorsally toward the tip; florets doubtfully reported as yellowish (Hieron.). — Hieron. in Engl. Bot. Jahrb. xxi. 332 (1895), xxviii. 573 (1901).

BOLÍVAR: on the volcano Turbaco, *Stübel*, no. 51, acc. to Hieron., l. c.
CAUCA: in dense woods on savannahs along the Rio Ortega, district of Popayan, alt. 1500–1800 m., *Lehmann*, no. 5971 (Berl., frag. Gr.).

Var. **typicum**. Leaves lanceolate, 5–6 cm. wide; heads 25–30-flowered. (Lit. and exsicc. as above.)

Var. **ovatifolium** Hieron. Leaves ovate, about 7 cm. broad, abruptly contracted to the cuneate base; florets fewer, 12–19.— Hieron. in Engl. Bot. Jahrb. xxviii. 573 (1901), as *ovatifolia*.

WITHOUT LOCALITY: *Triana*, no. 1450.

No material of this variety has been seen by the writer and the character has been compiled from the original description.

50. **E. amygdalinum** Lam. Suffruticose, either smooth or (in extra-limital forms) in varying degree pubescent or glandular, often viscid, 3–6 dm. high; stems erect, leafy, mostly simple to the inflorescence; leaves opposite, sessile, lance- or elliptic- or ovate-oblong, firmly chartaceo-coriaceous, brownish-green, mostly obtuse, subentire or undulate or crenate-serrate, veiny, 5–10 cm. long, 2–4 cm. wide; panicle terminal, somewhat fastigiately branched, 3–10 or more cm. in diameter; heads about 40-flowered, 7–8 mm. high; involucre turbinate-campanulate; scales about 40, linear, usually purple-tinged; florets rose-colored or lilac, rarely white.— Encyc. ii. 408 (1786); Bak. in Mart. Fl. Bras. vi. pt. 2, 312, t. 83 (1876), which see for extended synonymy; Hieron. in Engl. Bot. Jahrb. xxviii. 574 (1901). *E. loniceroides* HBK. Nov. Gen. et Spec. iv. 116 (1820). *E. amygdalinum*, forma *lonicerodes* [HBK.] Ktze. Rev. Gen. i. 337 (1891).

MAGDALENA: near Santa Marta, alt. 610 m., *H. H. Smith*, no. 614 (Gr.).
CUNDINAMARCA: eastern slope of the Andes of Bogotá, near Quetame, *André*, no. 881 (Gr.).

Huila: foot of the Cordillera Oriental, near Neiva, *Rusby & Pennell*, no. 477 (N. Y.).

El Valle: La Laguna near Palmira, Cauca Valley, alt. 1300 m., *Pittier*, no. 909 (Gr.).

Cauca: in dry places between Popayan and Pindamon, *Humboldt & Bonpland*, no. 1914 (Par., phot. Gr.); Buenos Aires, alt. 1000–1500 m., *Lehmann*, no. B. T. 1158 (N. Y.).

Depart. not indicated: *Lehmann*, no. B. T. 1283 (N. Y.); in clayey soil on eastern slope of the Cordillera Occidental, *Langlassé*, no. 71 (Gr.).

Rather attractive, highly variable species. Several formal variations, which have passed in different regions under many names, are summarized (briefly and by no means clearly) by Kuntze, l. c. In Colombia the plant appears to be exclusively of the typical smooth variety, but it exhibits strikingly different leaf-forms, namely 1) with rather narrowly oblong leaves, cuneate at base; 2) a broader-leaved form or state (corresponding to *E. loniceroides* HBK.) in which the leaves are widely oblong to ovate, abruptly contracted or rounded at base; and 3) an extreme of the preceding tendency with leaves nearly orbicular. The last is illustrated by André's no. 881, said to have whitish florets. These forms, while striking in their extremes, have little classificatory value, leaves of different shapes occurring on shoots from the same root.

51. **E. fuliginosum** HBK. Slightly woody rusty-tomentose climber; leaves opposite, lance-oblong, rather distantly denticulate, acuminate, cuneate at base, 15 cm. or more long, about a third as wide, green and scabrous above, dusky-tomentose beneath; veins pinnate, prominent, the veinlets reticulated; petiole 2.5 cm. long; panicle long-peduncled, divaricately branched, rusty-tomentose; heads about 25-flowered, sessile or shortly pedicelled, crowded; involucre hemispherical; scales oblong, obtuse, dorsally pubescent, ciliate, about 3-ranked; florets supposed to be white; achenes dark, 2 mm. long, hispid on the angles.— Nov. Gen. et Spec. iv. 110 (1820); Hieron. in Engl. Bot. Jahrb. xxviii. 572 (1901).

Tolima: in the Quindio Mountains near Alto de Guayabal and Quebrado de Toche, alt. 430–610 m., *Humboldt & Bonpland* (Par., phot. Gr.).

El Valle: at edge of dense woods near Tocotá, alt. 1600–2000 m., *Lehmann*, no. 7698, acc. to Hieron. l. c.

Cauca: in dense moist forests on western slopes of the Cordillera Occidental, near Popayan, alt. 1500–2000 m., *Lehmann*, no. 8509, acc. to Hieron.

Without locality: *Triana*, no. 1520, acc. to Hieron.

52. **E. popayanense** Hieron. Pithy and soft-wooded shrub reaching 3–4 m. in height; branches purplish or brownish-green,

deeply sulcate, glabrous, leafy; leaves opposite, petiolate, serrulate except at the cuneate base, acuminate, pinnately many-veined, 10–18 cm. long, 2.4–5 cm. wide, firm in texture; petiole 1–2 cm. long; heads 20–25-flowered, in ample sessile compound flattish-topped or decidedly convex corymbs (9–18 cm. in breadth); involucre campanulate, about 6 mm. high and thick; scales 3–4-seriate, stramineous, lanceolate, acute or acutish, often viscid; florets ochroleucous or white tinged with violet (Mayor); achenes dark, tapering toward the base, nearly or quite glabrous, 1.8 mm. long.— Hieron. in Engl. Bot. Jahrb. xl. 373 (1908); Heering, Mém. Soc. neuchât. Sci. Nat. v. 420 (1913).

ANTIOQUIA: talus-slopes of the Cafetal La Camelia, near Angelopolis, alt. about 1600 m., *Mayor*, no. 641, acc. to Heering, l. c.

EL VALLE: El Saladito, above Calí, road to Buenaventura, Cordillera Occidental, alt. 1400 m., *Pittier*, no. 772 (U. S.).

CAUCA: in thickets on plateau near Popayan, alt. 1600–1900 m., *Lehmann*, no. 5539, acc. to Hieron. l. c.

WITHOUT LOCALITY: *Triana*, no. 1227 (K.).

Sect. III. EXIMBRICATA (DC.) Hoffm. Involucre campanulate, turbinate, or subcylindric, seldom more than twice as long as thick; scales (persistent) 1–2(–3)-seriate, most of them subequal, but often 1–3 of the outermost considerably and progressively reduced. Receptacle flat or nearly so, glabrous.— Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 140 (1890). *Eupatorium* ser. *Eximbricata* DC. Prod. v. 164 (1836). *Kyrstenia* Neck. Elem. i. 81 (1790). *Batschia* Moench, Meth. 567 (1794). *Gyptis* Cass. Bull. Soc. Philom. 139 (1818). *Ageratiopsis* Sch. Bip. ex Benth. & Hook. f. Gen. ii. 246 (1873).

The separation of this section from the preceding, while practical for purposes of classification, is obviously artificial. The distinction, whether stated in terms of the greater equality of the involucral scales and the fact that they appear to be in fewer series, or based upon their relatively slighter imbrication, is incapable of precise definition and unaccompanied by concomitant differences either of habit or technical characters.

KEY TO SPECIES.

a. Leaves coriaceous, reticulated, oblong to elliptical (sometimes ovate in *E. rorulentum* and *E. vacciniaefolium*); shrubs, usually viscid or vernicose *b*.
  b. Heads 5–14-flowered or rarely (in nos. 58 and 59) 20–25-flowered *c*.

- *c.* Heads in an open pyramidal panicle................53. *E. amplum.*
- *c.* Heads in dense flat or rounded corymbs *d.*
  - *d.* Leaves soft-pubescent beneath *e.*
    - *e.* Leaves lance-oblong, 6–9 cm. in length; achenes copiously glandular on the faces as well as the ribs 54. *E. angustifolium.*
    - *e.* Leaves lance-oblong, 3.5–6 cm. in length; achenes not at all glandular on the faces.......55. *E. pomaderrifolium.*
    - *e.* Leaves ovate-oblong, 3-nerved from above the base 56. *E. rorulentum.*
  - *d.* Leaves glabrous beneath *f.*
    - *f.* Heads 5–6-flowered; internodes 1–3 mm. long; leaves rarely over 1.5 cm. long..........57. *E. vacciniaefolium.*
    - *f.* Heads 12–25-flowered; internodes 1–6 cm. long; leaves rarely less than 2 cm. long *g.*
      - *g.* Leaves 4–9 cm. long, the exserted veinlets on the lower surface rounded, not furrowed *h.*
        - *h.* Leaves lance-oblong to typically oblong, 2–3 cm. wide; inflorescence well overtopping the foliage..............................58. *E. fastigiatum.*
        - *h.* Leaves broadly elliptic-oblong, 3–3.5 cm. wide; inflorescence about equalled or often surpassed by the upper leaves..................59. *E. tinifolium.*
      - *g.* Leaves with the exserted veinlets on the lower surface furrowed *i.*
        - *i.* Leaves large, about 1.5 dm. long, coarsely toothed.........................60. *E. glyptophlebium.*
        - *i.* Leaves much smaller, 2–3.7 cm. long, finely crenate-serrate.......................61. *E. theaefolium.*
- *b.* Heads 30–40-flowered..............................62. *E. latipes.*

a. Leaves membranaceous, lanceolate to ovate-suborbicular, broadest below the middle; shrubs or more often perennial herbs *j.*

- *j.* Heads 5–19-flowered *k.*
  - *k.* Leaves cuneate at base, 3–3.5 cm. long..........63. *E. serratifolium.*
  - *k.* Leaves rounded or cordate at base, 6–18 cm. long *l.*
    - *l.* Heads in loose often leafy-bracted pyramidal panicles; leaves caudate-acuminate, the cauline 5–7 cm. wide *m.*
      - *m.* Leaves 3-nerved from the base.........64. *E. solidaginoides.*
      - *m.* Leaves 3-nerved from much above the base.65. *E. celtidifolium.*
    - *l.* Heads in dense flattish corymbs; leaves only acutish, the cauline 9–12 cm. wide....................66. *E. hylibates.*
- *j.* Heads 25–60-flowered *n.*
  - *n.* Leaves linear, alternate.......................67. *E. Trianae.*
  - *n.* Leaves broader, opposite (except sometimes a few of the uppermost) *o.*
    - *o.* Petioles very short, 1–3 mm. long in the middle cauline leaves, those of the lower leaves sometimes 5–6 mm. long *p.*
      - *p.* Pedicels finely pubescent, the hairs somewhat incurved or moderately spreading, attenuate, perceptibly (under a microscope) articulated, not gland-tipped...............................68. *E. gracile.*
      - *p.* Pedicels glabrous or nearly so....(68) *E. gracile*, v. *epilobioides.*
      - *p.* Pedicels densely pubescent, the hairs horizontally spreading, tipped with spherical glands........69. *E. sotarense.*

o. Petioles longer, mostly 0.8–5 cm. in length *q.*

- *q.* Leaves deltoid; achenes with supplementary ribs between the 5 chief angles or ribs ....70. *E. intercostulatum.*
- *q.* Leaves ovate-lanceolate to suborbicular; achenes 5-costate *r.*
  - *r.* Entirely glabrous or the branchlets and pedicels with traces of minute pubescence of incurved non-glandular hairs; leaves rounded at base; heads about 25-flowered ....71. *E. Dombeyanum.*
  - *r.* Puberulent at least in the inflorescence, the hairs gland-tipped; leaves 2–4 cm. long, obtuse, rounded, or subcordate at base ....72. *E. azangaroense.*
  - *r.* Puberulent; leaves rather large, as much as 1 dm. long and 8 cm. wide, cordate with an open sinus and shortly acuminate at the insertion; heads 4–6 mm. long, about 30-flowered ....73. *E. microcephalum.*
  - *r.* Villous with long spreading attenuate dark-jointed hairs; heads 25–45-flowered *s.*
    - *s.* Petioles 8–15 mm. long; leaves coarsely and crenately 7–10-toothed on each side.....74. *E. articulatum.*
    - *s.* Petioles (1.5–)2–6 cm. long; leaves serrately or crenately 12–18-toothed on each side *t.*
      - *t.* Heads 25–35-flowered, about 6 mm. high; pappus-bristles white, connate at base into a somewhat conspicuous ring; achenes usually rather copiously pubescent............75. *E. ibaguense.*
      - *t.* Heads 40–45-flowered, about 8 mm. high; pappus-bristles at first white but soon slightly reddish- or brownish-tinged, scarcely at all connate at base; achenes hispid on the angles 76. *E. pichinchense.*
  - *r.* Densely pubescent chiefly with gland-tipped hairs; leaves deeply cordate by a closed sinus; heads 50–60-flowered ....77. *E. Apollinairei.*

53. **E. amplum** Benth. Smooth and viscid shrub, 1–2 m. high; branches nearly or quite terete, dark-purple and very sticky, leafy to the terminal sessile pyramidal panicle; leaves opposite, petiolate, firm, coriaceous, glabrous and with a fine prominulent reticulation on both surfaces, oblong, acuminate, rounded at base, serrulate, 1.5–2 dm. long, 3–4 cm. wide or more, pinnately veined; panicle 1–2 dm. in diameter, lax; heads 11–15-flowered, 6 mm. high, about 3 mm. in diameter; scales of the campanulate involucre 1-nerved, subequal, ciliate, the outermost linear, the intermediate oblong, acutish, the innermost spatulate; corolla 4 mm. long (young), beset with sessile glands on the proper tube.— Pl. Hartw. 200 (1845).

CUNDINAMARCA: on the Cordillera de los Andes, near Bogotá, *Hartweg*, no. 1103 (sk. and fragm., Gr.).

WITHOUT LOCALITY: *Triana*, no. 1226 (K.).

54. **E. angustifolium** (HBK.) Spreng. Shrub or small tree attaining 6 m. in height (André), grayish-woolly; leaves opposite, petiolate, oblong or elliptic, acute or obtusish, entire or undulate or sinuate-dentate above the entire rounded base, 6–10 cm. long, 2.5–5 cm. wide, pinnately veined, glabrate and obscurely reticulated above, gray-tomentose beneath; petiole stoutish, 5–8 mm. long; heads about 7-flowered, 1 cm. long, in compound terminal corymbs; involucral scales about 11, subequal, 3–5 mm. long, bluntly pointed, the outer pubescent on the back; florets much exserted; corolla with short proper tube and longer slightly ampliated then somewhat contracted throat; achenes beset with sessile glands.— Syst. iii. 415 (1826). *Cacalia asclepiadea* L. f. Suppl. 352 (1781). *Mikania angustifolia* HBK. Nov. Gen. et Spec. iv. 138 (1820). *E. coperense* Hieron. in Engl. Bot. Jahrb. xxi. 330 (1895), see Robinson, Proc. Am. Acad. xlii. 37 (1906).

BOYACÁ: Páramo de Coper, *Stübel*, no. 1629 (Berl., fragm. Gr.).

CUNDINAMARCA: Montserrate, near Bogotá, from the herb. of *de Parseval-Grandmaison*, no. 46 (Gr.); at foot of the Cordillera Occidental, near Bogotá, alt. 2800 m., *André*, no. 888 (Gr.); Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, nos. 69 (U. S.) and 72 (Gr.).

TOLIMA: between Ibagué and Cuesta de Tolima, *Humboldt & Bonpland* (Par., phot. Gr.).

WITHOUT LOCALITY: *Mutis* (Linn. Soc., phot. Gr.).

A characteristic species, but, as now placed in its proper genus, very ineptly named.

55. **E. pomaderrifolium** Benth. Much branched firm-wooded shrub; branches very leafy, round, gray-tomentellous; leaves opposite, petiolate, elliptical, entire, acutish, mucronate, 3.5–6 cm. long, 1–2.2 cm. wide, chartaceo-coriaceous, pinnately veined, glabrous (except on midrib) and reticulated above, thinly gray-tomentose beneath; petiole slender, 3–10 mm. long; heads about 14-flowered, 9 mm. high, in dense compound leafy-bracted round-topped corymbs; involucral scales about 14, subequal, loosely imbricated, lance-oblong, pubescent, claret-colored toward the obtusish apex, 2–3 of the outermost much smaller, slightly separated bractlets; corollas inferred to be purple-tinged, with short gland-sprinkled proper tube and longer upwardly villous cylindrical throat; achenes beset on the angles with sessile glands.— Pl. Hartw. 199 (1845); Heering, Mém. Soc. neuchât. Sci. Nat. 419 (1913).

CUNDINAMARCA: near Bogotá, *Hartweg*, no. 1098 (K., phot. Gr.); on mountains near Bogotá, *Holton*, no. 321 (Gr.), slope of Montserrate, above Bogotá, alt. 2800 m., *Mayor*, no. 71, acc. to Heering, l. c.

56. **E. rorulentum** Robinson. Shrub or tree with terete hard-wooded fuscous branches and somewhat fastigiate sordid-tomentose branchlets; leaves opposite suborbicular-ovate, obtuse, serrate except at the cordate base, coriaceous, somewhat 3-nerved from well above the base (but with 1–2 pairs of lesser and pinnately arranged veins between the forking of the lateral nerves and the base), 2–2.8 cm. long, 1.5–2 cm. wide, finely reticulated on both surfaces, densely sprinkled with lucid globular sessile glands or resinous atoms but otherwise glabrous above, softly tawny-pubescent and more sparingly atomiferous beneath; petiole 1–3 mm. long; heads about 10-flowered, clustered in rather dense round-topped corymbs terminating the branchlets; involucral scales 7–10, subequal, lance-oblong, acutish, dorsally tawny-tomentose; florets inferred to be whitish; achenes tapering downward, beset on the angles with shortly stiped glands.— Proc. Am. Acad. liv. 255 (1918).

Cundinamarca: at Guadalupe, alt. 2900 m., *Bros. Apollinaire & Arthur*, no. 27 (Gr.).

Obviously near to *E. prunifolium* HBK. of Ecuador, which, however, has longer relatively narrower subentire leaves, rounded but not cordate at base.

57. **E. vacciniaefolium** Benth. Low fastigiately branched evergreen shrub 1 m. or less in height; branches rusty-hirsute, very leafy, the internodes exceedingly short; leaves opposite, subsessile, elliptic-ovate, narrowed to an obtuse apex, rounded at base, crenately few-toothed, coriaceous, green on both surfaces, 1–2 cm. long, 5–10 mm. wide; petiole 2 mm. long; heads 5–6-flowered, in dense round-topped terminal corymbs; involucral scales oblong, subequal, loosely imbricated, ciliolate, the tip and margins often claret-colored; achenes glabrous (Benth.) or hispid on the angles.— Pl. Hartw. 200 (1845). *E. confertifolium* Klatt, Abh. naturf. Ges. Halle, xv. 324 (1882), & in advance reprint p. 4 (1881).

Cundinamarca: in Cordillera de los Andes, near Bogotá *Hartweg*, no. 1104; in mountains near Bogotá, *Holton*, no. 310 (Gr.).
Without locality: *Triana*, no. 3 (Gr.).

An attractive little alpine undershrub, easily distinguished from the related species by its small thick leaves, which are very close together.

58. **E. fastigiatum** HBK. Smooth shrub with angulate ascending leafy branches; leaves opposite, lance-oblong to typically oblong,

serrate except at the mostly bluntish sometimes slightly cuspidate tip and cuneate to abruptly narrowed or almost rounded base, 4–6 cm. long, 1.5–3 cm. wide; petiole slender 6–13 mm. long; corymb erect, flattish-topped, fastigiately branched, 7–20 cm. in diameter; heads crowded, pedicelled, about 12-flowered; scales narrowly oblong, obtuse, thin, viscid, often vernicose, in 2–3 subequal series; florets much exserted; corollas white.— Nov. Gen. et Spec. iv. 125, t. 347 (1820).

CUNDINAMARCA: Guadalupe, *Bros. Apollinaire & Arthur*, nos. 84 (U. S.) and 86 (Gr.).

NARIÑA: on an excursion to the volcano of Cumbal, *Stübel*, no. 436 (Berl., fragm. Gr.).

WITHOUT LOCALITY: *Triana*, nos. 40 (Gr.) and 1229 (K.).

[Ecuador, Peru.]

By obvious clerical error Kunth in HBK. Nov. Gen. et Spec. iv. 125 (1820), records the type of this species as from " frigidis montium Novo-Granatensium," but the more detailed locality cited, namely " inter pagum Guancabamba and Paramo de Guamani " makes it clear that the specimen in question came from northern Peru.

59. **E. tinifolium** HBK. Similar in many ways to the preceding and likewise with considerable resinous or varnish-like viscidity; leaves larger and much more broadly elliptic, 7–10 cm. long, half as wide, thin-coriaceous, reticulate-veiny on both surfaces, usually with 2 pairs of pinnately arranged more prominent curving intramarginal nerves somewhat above the base; heads much as in the last, but in smaller more compact less fastigiately branched round-topped corymbs; flowers white.— Nov. Gen. et Spec. iv. 133 (1820). *E. Lehmannianum* Klatt in Engl. Bot. Jahrb. viii. 34 (1887).

CUNDINAMARCA: Ubaté, 3 Jan. 1853, *Holton* (N. Y.), Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, no. 32 (Gr.).

WITHOUT LOCALITY: *Humboldt & Bonpland* (Par., phot. Gr.), *Lehmann*, no. C11. (Gr.).

60. **E. glyptophlebium** Robinson. Shrub with terete flexuous tawny-tomentulose pithy branches; leaves pale green, opposite, petiolate, oblanceolate-oblong, obtuse, coarsely serrate-dentate except at the entire slightly narrowed then rounded finally short-cuneate base, essentially glabrous except for the tomentulose midrib, thin-coriaceous, 1.5 dm. long, a third as wide, sprinkled with minute lucid resinous globules, the finely reticulated veinlets exserted both above

and beneath, being on the under surface furrowed (under a lens); petioles 1.5 cm. long; heads about 14-flowered, 10–11 mm. high, slender-pedicelled, nodding in dense compound trichotomous leafy-bracted corymbs (about 13 cm. in diameter); involucre cylindrical, 5 mm. high, gray-green, pubescent; scales 10–12, linear, subequal, scarcely imbricated, ciliate, obtusish; corollas about 6 mm. long, white with roseate tinge; proper tube exceeded by the gradually enlarged then slightly contracted throat; achenes 4–5 mm. long, remotely knobbed with sessile glands on the ribs, otherwise glabrous; pappus-bristles 5–6 mm. long, roseate, minutely scabrous.— Proc. Am. Acad. liv. 245 (1918).

CUNDINAMARCA: hillside near Tequendama, alt. 2500–2700 m., *Pennell*, no. 2641 (Gr.).

Sharing with *E. theaefolium* the peculiar trait of having the veinlets on the under surface of the leaves exserted but furrowed as if channelled by an engraver's tool. Hence the name.

61. **E. theaefolium** Benth. Compactly branched shrub 1–1.2 m. high; stem terete, hard-wooded; cortex grayish-brown; branchlets slender, flexuous, rusty-pubescent and somewhat glandular; leaves opposite, small, 2–3.5 cm. long, 9–12 mm. wide, oblong, acutish at both ends or roundish at base, crenate-serrate, puberulent on the midnerve and sprinkled on both surfaces with glistening sessile glands, finely reticulated, the veinlets beneath prominulent and finely sulcate; heads small, pedicellate, about 12-flowered, 8 mm. high, in many small round-topped corymbs terminating the branches; scales few, lance-linear, acutish, subequal, viscid-pubescent dorsally; florets much exserted; corollas apparently white; achenes dark brown, 3 mm. long, minutely granular on the angles.— Pl. Hartw. 199 (1845).

CAUCA: collected on the ascent to Sotará, in the Prov. of Popayan, *Hartweg*, no. 1101 (K., sk. and phot. Gr.).
[Venezuela.]

62. **E. latipes** Benth. Viscid undershrub 3–9 dm. high, with decumbent ascending leafy stem terminating in a dense or at length open fastigiately branched corymb; leaves opposite, oval-oblong, acutish to very obtuse at tip, rounded at base, serrulate, 3–7 cm. long, 2.2–3.7 cm. wide, coriaceous, pinnately veined, prominulent-reticulated and punctate beneath; petiole 3–5 mm. long, broad, concave above, often hairy and sometimes viscid; bracts spatulate to linear; heads pedicelled, somewhat larger and more numerously flowered

than in the two preceding, but otherwise similar; flowers pinkish (Rusby & Pennell).— Pl. Hartw. 200 (1845).

Cundinamarca: in Cordillera de los Andes, near Bogotá, *Hartweg*, no. 1106 (K.), *Holton*, no. 311 (Gr.), *Rusby & Pennell*, no. 1307 (N. Y.); shrubby slope, Chapinero, alt. 2700–2800 m., *Pennell*, no. 2039 (Gr.).
Without locality: *Triana*, nos. 19 (Gr.) and 1236 (N. Y.).

Varying from smoothish to pubescent, the hairs when present being tawny and stiffish, occurring chiefly below the middle of the stem and on the young branches about the base. The species is suspiciously close to *E. viscosum* HBK., supposed to have come from Ecuador (see p. 361).

63. **E. serratifolium** (HBK.) DC. Smooth shrub with opposite curved-ascending striate and somewhat hexagonal branches; leaves opposite, petiolate, rhombic-ovate, acuminate, about 3 cm. long, incisely serrate except toward the cuneately narrowed base, membranaceous, smooth, 3-nerved and reticulate-veiny; petiole 6–8 mm. long; heads numerous, about 5-flowered, in terminal flattish-topped trichotomous compound corymbs; involucre short-cylindric; scales about 5, narrowly oblong, blunt, sticky, ciliate but otherwise smoothish; achenes dark, 2 mm. long, hispid on the angles.— Prod. v. 181 (1836). *Mikania serratifolia* HBK. Nov. Gen. et Spec. iv. 138 (1820).

Tolima? near Mariquita? *Humboldt & Bonpland* (Par., poor phot. Gr.).

As yet known only from the original material of uncertain origin, but doubtfully supposed by Kunth to have been collected in the place cited and at an altitude of about 1000 m.

64. **E. solidaginoides** HBK. Slender-stemmed shrub, reaching 3 m. in height (André); branches subterete or obscurely hexagonal, finely pubescent; internodes usually 4–10 cm. long; leaves opposite, slender-petioled, ovate, caudate-acuminate, rounded or cordate at base, dentate, thin, membranaceous, 5–12 cm. long, half as wide, subglabrous or hirtellous above, sparingly to rather densely pubescent beneath; petioles 1–3 cm. long; the axils often proliferous; panicle terminal, leafy-bracted, pyramidal, its branches widely spreading; heads small, on filiform pedicels, disposed in often subglobose glomerules on short secondary branchlets; florets 10–15, greenish- to yellowish-white, much exserted; involucral scales about 12, subequal, oblong, acute, green or pinkish, thin.— Nov. Gen. et Spec. iv. 126 (1820). *E. filicaule* Sch. Bip. ex Gray, Proc. Am. Acad. xxi. 384 (1886). *E. stipuliferum* Rusby, Mem. Torr. Bot. Club, iv. 210 (1895).

Ophryosporus solidaginoides (HBK.) Hieron. in Engl. Bot. Jahrb. xxix. 4 (1900), see Robinson, Proc. Am. Acad. xlii. 27 (1906).

HUILA: around Huila, an Indian village in the Rio Paez valley, Tierra Adentro, alt. 1600–1900 m., *Pittier*, no. 1245 (Gr.).

CAUCA: Quebrada de Dolores, alt. 1800 m., *André*, no. 2832 (Gr.).

WITHOUT LOCALITY: *Triana*, no. 1185 (N. Y.).

[Mexico to Venezuela and Bolivia.]

65. **E. celtidifolium** Lam. Shrub or slender tree with slender grayish stems and spreading pale-green to dull ivory-white branches, glabrous to the inflorescence; leaves opposite, ovate-oblong, caudate-acuminate, thin, firmish in texture, green and glabrous on both sides or slightly pubescent on the nerves beneath, serrate-dentate, 1–1.5 dm. long, 3–5 cm. wide, 3-nerved from well above the base and with small intramarginal as well as transverse veins; panicles terminal and to some extent lateral; heads small, about 11-flowered; involucre narrowly campanulate, 2.7 mm. high; scales about 10, oblong, obtusish, subequal (usually 1–2 of the outermost lanceolate and much shorter); florets much exserted; corollas white.— Encyc. ii. 406 (1786); Hook. f. & Jacks. Ind. Kew. i. 916 (1893), where attributed to Colombia. *Mikania verrucosa* Spreng. Syst. iii. 423 (1826).

[Var. **typicum**. Pedicels and branches of the inflorescence glabrous; achenes hispid on the angles but nearly or quite glabrous on the faces].

[Lesser Antilles, e. g. Martinique, Guadeloupe, Dominica.]

Var. **hirtellum** Robinson. Pedicels and branches of the inflorescence puberulent; leaves with traces of pubescence at least on the midnerve beneath; achenes hirtellous on the faces as well as the ribs.— Proc. Am. Acad. liv. 238 (1918).

MAGDALENA: at Minca, Prov. Santa Marta, alt. 915 m., *Schlim*, no. 909 (K., phot. Gr.); locally common in dry forest near Bonda, below 150 m., *H. H. Smith*, no. 525 (Gr., Mo.).

It is probably to this hirtellous form that the Index Kewensis refers in accrediting the species to "N. Granat." Except in the matter of pubescence the plant of Colombia agrees closely with typical material from the Antilles.

66. **E. hylibates** Robinson. Soft-wooded shrub, 1.2–2.4 m. high; foliage yellow-green; stems thick, pithy, tawny-woolly; internodes 8 cm. or more in length; leaves large, opposite, long-petioled, ovate-oblong, acutish, rounded or subcordate at base, crenate-dentate, 11–

18 cm. long, 7–12 cm. wide, smoothish and green above, much paler, tawny-gray, and tomentose beneath; petiole 5 cm. or more in length; heads about 14-flowered, 7 mm. high, in a dense terminal trichotomous corymb 1.5–2 dm. wide; corollas white, the proper tube somewhat exceeded by the campanulate-cylindrical throat; achenes dark, smooth on the faces.— Proc. Am. Acad. liv. 246 (1918).

MAGDALENA: open places in the border of forest, Rio Frio, alt. 2300–2750 m., *Kalbreyer*, no. 1956 (K., phot. Gr.).

67. **E. Trianae** Robinson. Presumably herbaceous perennial (base unknown); stems terete, flexuous, covered with very short purplish-brown tomentum; leaves alternate, lance-linear, 6–10 cm. long, 5–10 mm. wide, attenuate at both ends, obscurely and remotely denticulate or entire, reticulate-rugulose above, paler and sordidly gray-tomentose beneath; petiole 2–3 mm. long; heads about 28-flowered, 5 mm. high and thick, in dense subsessile or shortly peduncled globose glomerules together forming an irregular corymb.— Proc. Am. Acad. liv. 260 (1918).

"NEW GRENADA"; without more precise locality, *Triana*, no. 1196 (K., phot. Gr.).

Exceedingly different from any other Colombian species of the genus and easily recognized by its narrow alternate leaves and small sessile heads. In habit suggesting a *Vernonia*, but by character clearly a *Eupatorium*.

68. **E. gracile** HBK. Slender usually several-stemmed decumbent or suberect perennial 3–8 dm. high, essentially herbaceous or slightly lignescent, finely pubescent or glabrous throughout; leaves opposite, ovate to (rarely) lanceolate, acute or acuminate, abruptly narrowed to an obtusish or rounded base, crenately or sharply serrate, 1.5–2.5(–4) cm. long, 7–20 mm. wide, membranaceous, usually glabrous, tending to darken in drying, 3-nerved from slightly above the base; petiole 1–6(–10) mm. long; internodes, especially the upper, elongated, much exceeding the leaves; branches of the inflorescence ascending, slender, flexuous, trichotomously divided, the branchlets almost filiform, mostly 3-headed; pedicels at maturity often 1–2.5 cm. long, usually curved; heads often nodding, 30–40-flowered, 6–8 mm. high, 4–5 mm. in diameter; involucre campanulate; scales subequal, lance-oblong to linear, thin, closely 2(–3)-ribbed, acutish to attenuate; corollas 3 mm. long, glabrous, the slender proper

tube about equalling the distinctly cylindric-campanulate throat; achenes slightly attenuate toward the base and perceptibly contracted just below the summit, hispidulous on the angles or quite glabrous; pappus-bristles 20-25.— Nov. Gen. et Spec. iv. 124 (1820); Klatt in Engl. Bot. Jahrb. viii. 34 (1887).

CUNDINAMARCA: in temperate region near Guaduas, alt. 1100 m., *Humboldt & Bonpland* (Par., phot. Gr.); Bogotá, *Rusby & Pennell*, no. 1306 (N. Y.); shrubby hillside, southwest of Sibate, alt. 2800–2900 m., *Pennell*, no. 2390 (Gr.).

HUILA: Las Escaleretas, Moras Valley, Rio Paez basin, Tierra Adentro, alt. 2500–3000 m., *Pittier*, no. 1380a (U. S.).

WITHOUT LOCALITY: *Triana*, no. 1188 (N. Y.); *Lehmann*, no. CX. (Gr.).

Persistent search has failed to disclose between the following varieties any constant or natural differences which would justify their maintenance as separate species. .

Var. **typicum**. Stem, branches, pedicels, and often outer involucral scales, as well as the margins, nerves, and rarely the surface of the leaves finely pubescent, the hairs delicate, short, dark, purplish or brownish, ascending or somewhat spreading.— Lit. and exsicc. as above.

Here, provisionally and somewhat doubtfully, may be placed *E. sotarense*, var. *breviflora* Hieron. in Engl. Bot. Jahrb. xxviii. 574 (1901), known as yet only from the original material from open thickets on the slopes of Mt. Guálcala in the district of Tuquerres, alt. 2500–2900 m., *Lehmann*, no. 5195 (Berl., fragm. Gr.). Although the heads are slightly smaller than usual in the species and the leaves a trifle larger and more pubescent, these differences are of degree rather than kind, and are no greater than are usually bridged by complete intergradation. The pubescence of the pedicels, while more copious, is precisely of the sort prevalent in *E. gracile*, and not gland-tipped as in the typical *E. sotarense*.

Var. **epilobioides** (HBK.) Robinson, comb. nov. Glabrous throughout or with only minute vestiges of pubescence on the branches of the inflorescence.— *E. epilobioides* HBK. Nov. Gen. et Spec. iv. 125 (1820). *E. caducisetum* DC. Prod. v. 165 (1836).

CUNDINAMARCA: in temperate region near Guaduas, *Humboldt & Bonpland* (Par., phot. Gr.); about Santa Fé de Bogotá, [specimen from herb. of] *Delessert* (DC., phot. Gr.); at the falls of Tequendama, 8–11 Dec. 1852, *Holton* (K., N. Y.); near Bogotá, in mountains, 18 Nov. 1852, *Holton* (N. Y.); near Bogotá, alt. 2700 m., *Bros. Apollinaire & Arthur*, no. 93 (Gr.); dry open hillside, Quetame, alt. 1300–1500 m., *Pennell,* no. 1871 (Gr.), a doubtful specimen but clearly related although with slightly longer petioles.

WITHOUT LOCALITY: *Triana,* no. 1187 (K.).

The type-specimen of *E. caducisetum* shows it to have been a somewhat more loosely grown individual than the type of *E. epilobioides,* but the differences, notably in the length of the internodes and petioles, are completely bridged by intermediates now at hand, and are of a kind permitting no clear or natural distinction.

69. **E. sotarense** Hieron. Erect, herbaceous or suffruticose; stem terete, somewhat glandular-pubescent; leaves opposite or ternate, ovate, acuminate, rounded at the base, 2.5–3 cm. long, 2 cm. wide, crenate-serrate, nearly glabrous except for a scattered pubescence on the nerves, 3-nerved from the base, the lateral nerves forking; branches of the inflorescence and pedicels closely beset with dark divaricately spreading gland-tipped hairs; pedicels 3–5 mm. long; heads about 30-flowered, 7 mm. high; involucral scales about 18, lance-linear, 2–3-ribbed, the outer dorsally covered with dark purplish-brown more or less glandular tomentum, acute; corollas about 4 mm. long, with slender proper tube slightly exceeded by the cylindric-campanulate throat; achenes at maturity black, 2.5 mm. long, slightly tapering at both ends.— Hieron. in Engl. Bot. Jahrb. xxviii. 574 (1901). *E. soratense* Hieron. l. c. xxi. 333 (1895), not Klatt.

CAUCA: on the cone of the volcano Sotará, alt. 4000 m., *Stübel,* no. 329b (Berl., fragm. Gr.).

Obviously near *E. gracile,* but to be distinguished by the more copious and gland-tipped pubescence on the inflorescence.

70. **E. intercostulatum** Robinson. Shrub, very finely grayish-puberulent, not glandular; stems subterete, costate, grayish-buff; branches ascending, when young hexagonal; leaves opposite, petiolate, deltoid, 3–3.5 cm. long, nearly as wide, coarsely crenate-dentate except at the acute apex and broad truncate or very shallowly subcordate base, short-acuminate at the insertion, 3-ribbed from the base, sparingly pulverulent-puberulent on both surfaces, scarcely paler beneath, membranaceous; petiole about 1 cm. long; corymbs dense, round-topped, many-headed, terminal and single or supplemented by smaller corymbs from the upper axils; heads pedicellate, about 15-flowered, 6.5 mm. high, 6 mm. in diameter; involucre campanulate, 3 mm. high; scales lance-linear, acute, subequal except 2–3 of the considerably reduced outermost, pulverulent; corollas (presumably

white or nearly so) glabrous, 3.5 mm. long, with short proper tube and longer distinctly enlarged throat; achenes 2.3 mm. long, at maturity almost black, hispidulous, prominently 5-costate-angulate and with 3–5 secondary ribs each in an interval between the primary. — Proc. Am. Acad. liv. 247 (1918).

INTENDENCIA DE CHOCO: Truandó, *Schott*, no. 3 (Field Mus., phot. Gr.).

A species clearly of the genus *Eupatorium*, yet somewhat anomalous in the supernumerary ribs of the achenes.

71. **E. Dombeyanum** DC. Nearly glabrous or somewhat hirtellous in the inflorescence and on the nerves of the leaves, 6–9 dm. high (Smith), herbaceous or slightly shrubby; stems erect, terete; internodes 5–6 cm. long; branches slender, bearing 1–3 pairs of leaves and terminating in open compound cymes together forming a loose leafy-bracted panicle; leaves opposite, ovate, attenuate-acuminate, sharply serrate except at the rounded base, green and very smooth on both surfaces, 3-5-nerved from slightly above the base, membranaceous, 6–8 cm. long, about 3 cm. wide; petiole slender, 1.5–2.3 cm. long; bracts linear; pedicels filiform; heads often nodding, about 25-flowered; involucre campanulate; scales subequal, lance-linear, acute, thin; corollas inferred to be purplish but perhaps white; achenes black, glabrous or slightly hispid on the angles toward the summit.— Prod. v. 167 (1836).

MAGDALENA: in clearings, not common, Las Nubes near Santa Marta, alt. 1372 m., *H. H. Smith*, no. 621 (Gr., U. S., Mo.).

TOLIMA: edge of woods, alt. 2000–2300 m., Murillo, *Pennell*, no. 3190 (Gr.).

Originally described from material collected by Dombey in South America, presumably in Peru. The type in the DeCandollean Herbarium was examined some years ago by the writer and there is a clear photograph of it in the Gray Herbarium. With this, as well as with the original diagnosis, the Colombian plants just cited correspond closely in all significant details.

72. **E. azangaroense** Sch. Bip. Puberulent shrub or undershrub 3–5 or more dm high; leaves lanceolate- to triangular-ovate, subacuminate at the apex, obtuse or rounded or subcordate at the base, coarsely serrate, 2–4 cm. long; corymbs few-headed; heads many-flowered; involucral scales more than 20, linear-lanceolate, acuminate, glabrous or glandular-puberulent, almost equal.— Bonplandia, iv. 54 (1856), without char.; Wedd. Chlor. And. i. 217 (1857), where described.

MAGDALENA: on the Sierra Nevada de Santa Marta, *Funck*, no. 391, acc. to Weddell, l. c.

[Ecuador, Peru, and Bolivia, acc. to Weddell, l. c.].

A poorly known species, in its described characters not clearly distinguished from the earlier and variable *E. glechonophyllum* Less., which appears to extend from the Andes of Ecuador to the coast of central Chili. No Colombian material of *E. azangaroense* has been seen by the writer.

73. **E. microcephalum** Regel. Erect, suffruticose, paniculately branched, puberulent on stem and terete branches; leaves opposite, petioled, cordate or "cordate-ovate," 3-nerved, coarsely crenate-toothed, acuminate to an acutish tip, entire at base and cuneate-attenuate at the insertion of the petiole, hispid with single hairs on both surfaces, as much as 1 dm. long and 8 cm. wide; cymes axillary and terminal, disposed in a panicle; peduncles pubescent, exceeding the leaves; heads 4–6 mm. high, about 30-flowered; involucral scales lance-linear, acute, hirtellous on the back; florets white; achenes hirtellous on the angles.— Ind. Sem. Hort. Petrop. 1860, p. 35 (1860).

COLOMBIA: described from plants raised at the Imperial Gardens in Petrograd and thought to have been from Colombia.

Known only from the original description, of which the above character is a condensed compilation.

74. **E. articulatum** Sch. Bip. Somewhat lignescent, erect or ascending, perennial, 3–4 dm. high, villous, the hairs jointed; leaves opposite, petiolate, membranaceous, broadly ovate, acuminate at apex, rounded or slightly cordate at base, coarsely crenate-dentate, sprinkled above with subsessile glands, below sparingly villous especially on the (mostly 5) nerves, at most 5.5 cm. long, 4 cm. wide; heads 30–40-flowered, corymbose or cymose at the ends of the stem and branches; scales of the involucre nearly equal, about 20, lance-linear, pale-green and tending to be scarious, acute, 3-ribbed, dorsally pubescent, the outermost reduced and more or less distant on the pedicel; corollas purplish; the slender proper tube slightly exceeded by the somewhat enlarged throat; achenes roughened on the angles; pappus bristles caducous.— Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xl. 385 (1908).

TOLIMA: near Ibagué, *Humboldt & Bonpland*, acc. to Hieron., l. c.

[Venezuela to Peru.]

A species unknown to the writer; the character condensed from the original diagnosis.

75. **E. ibaguense** Sch. Bip. Herbaceous, branched; stem terete, brown, pithy, spreading-villous, the hairs attenuate, non-glandular, jointed; internodes 8–11 cm. long; leaves opposite, petiolate, ovate, acuminate, serrate or crenate-dentate (teeth of the cauline 12–16 on each side, often again 1–2-toothed), rounded or subtruncate at the base, thin-membranaceous, green on both surfaces, scarcely paler beneath, spreading-villous on the nerves and veins to nearly glabrate, 6–8.5 cm. long, 3.5–6 cm. wide, 3-nerved from the base, the lateral nerves quickly again branched; corymbs terminal and from several of the upper axils, rather dense; heads about 30-flowered; pedicels slender, pubescent, 2–6 mm. long; involucral scales 12–16, lance-linear, acutish, subequal, thin, pale-green and somewhat stramineous, pubescent especially toward the acutish erose tip; corollas white, villous toward the summit, the slender tube about equalling the enlarged subcylindric throat; pappus-bristles about 28, white, united at the base into a little white disk or ring; achenes black, hispid.— Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xl. 384 (1908).

CAUCA: Capilla-highlands of Popayan, alt. 1700–1800 m., *Lehmann*, no. B. T. 1155 (N. Y.).

WITHOUT LOCALITY: *Lehmann*, no. 5194 (N. Y.); *Linden*, no. 2219, acc. to Sch. Bip., l. c.; *Karsten*, acc. to Sch. Bip., l. c.

[Venezuela.]

A species in technical characters close to the following and also nearly related to the Mexican *E. pazcuarense* HBK.

76. **E. pichinchense** HBK. Herbaceous perennial, flexuous and said to be climbing, villous; the hairs long, soft, attenuate, not gland-tipped, but with dark articulations; leaves opposite, petiolate, broadly ovate or suborbicular, acuminate, rounded or cordate with an open sinus at the base, serrate (teeth about 14 on each side, mostly sharp, sometimes rounded, often again 1–2-toothed), 3-nerved, finely and sparingly appressed-villous and green on both surfaces, 5–6 cm. long, 3–4 cm. wide; petiole 2–4 cm. long, villous; heads 40–45-flowered, pedicellate, in terminal trichotomous rather dense corymbs; involucral scales 15–20, lance-linear, subequal, thin, acute, ciliate, dorsally villous, 1–3 of the outermost shorter, narrow and bractlike; corollas white, with slender proper tube somewhat exceeded by the cylindric-campanulate throat; achenes slender, dark-brown to almost black, upwardly hispid on the angles.— Nov. Gen. et Spec. iv. 122 (1820); DC. Prod. v. 165 (1836).

MAGDALENA: open places, clearings and ridges, Sierra del Libano near Santa Marta, alt. 1830 m., *H. H. Smith*, no. 1994 (Gr., U. S.); San Sebastian near Santa Marta, *Funck*, no. 524 (K.), immature and doubtful.
[Ecuador.]

The specimens comprising the sheet of Smith's no. 1994 in the U. S. National Museum show considerable variation in the leaf-contour, the basal sinus being deeper and narrower and the teeth more rounded in portions of this material than in any other seen. The identity in the pubescence, floral characters, etc., indicates that this is individual variation rather than the mixing of species.

77. **E. Apollinairei** Robinson. Stems terete, flexuous as if weakly scandent, closely covered with short spreading stipitate glands; internodes 1–1.5 dm. or more long; leaves opposite, petiolate, deltoid-suborbicular, bluntly short-acuminate, deeply cordate by a narrow sinus, coarsely crenate, 5–9-nerved, green and smoothish above, slightly paler and glandular-tomentose on the veins beneath, 7–13 cm. long and broad; petioles 3.5–7 cm. long, densely glandular-tomentose; heads about 58-flowered, slender-pedicelled, 7–10 mm. high, in long-peduncled moderately convex many-headed compound corymbs (1 dm. or more in diameter); involucre campanulate; scales about 24, subequal, lance-linear, attenuate, becoming stramineous, dorsally pubescent, the hairs both jointed and gland-tipped; corollas white, pubescent externally on the limb; the slender proper tube about equalling the enlarged cylindric throat; achenes 2 mm. long, hispid on the angles.— Proc. Am. Acad. liv. 236 (1918).

CUNDINAMARCA: near Bogotá, alt. 2700 m., *Bros. Apollinaire & Arthur*, no. 94 (Gr., U. S.), in mountains near Bogotá, *Holton*, no. 312 (N. Y.).
WITHOUT LOCALITY: *Triana*, no. 22 (Cr.).

Sect. IV. PRAXELIS (Cass.) Benth. Involucre campanulate- or turbinate-subcylindric; the scales mostly acute, imbricated in 3–4 graded series, deciduous before the florets loosen from the receptacle. Summit of the peduncle cylindrical, exhibiting after the fall of the involucral scales depressed scars mostly rhombic in form. Receptacle moderately convex to conical, glabrous.— Benth. acc. to Bak. in Mart. Fl. Bras. vi. pt. 2, 241 (1876); Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 140 (1890). *Praxelis* Cass. Dict. xliii. 261 (1826). *Ooclinium* DC. Prod. v. 133 (1836).— Weedlike annuals of somewhat characteristic habit, mostly decumbent and usually setose, the heads few, singly terminating what for the genus are unusually long peduncles.

Key to Species.

Cauline leaves ovate, petiolate........................78. *E. pauciflorum*.
Cauline leaves lance-linear, sessile or nearly so...........79. *E. kleinioides*.

78. **E. pauciflorum** HBK. Weak hispid-pubescent decumbent annual 2–5 dm. high; leaves opposite, short-petioled, ovate, acutish, sharply serrate (the teeth few, often only 3–4 on each side), acutish at the base, 1.5–6 cm. long, two-thirds as wide, sparingly to rather densely covered with jointed white long non-glandular hairs; heads about 30-flowered, long-pedicelled, erect, mostly in irregular 3–5-headed terminal cymes; involucral scales stramineous, about 3-seriate, 3-nerved, the inner obtusish and usually mucronate, the outer acute, all promptly deciduous; corollas bluish-white or pale lilac; achenes black, 2 mm. long, 5-angled but often somewhat flattened, tapering somewhat toward the base and contracted at the summit, upwardly hispid on the faces.— Nov. Gen. et Spec. iv. 120 (1820). *Praxelis villosa* Cass. Dict. xliii. 261 (1826). *Bulbostylis ? pauciflora* (HBK.) DC. Prod. v. 139 (1836). *Ooclinium depressum* Gardn. in Hook. Lond. Jour. Bot. vi. 437 (1847). *E. urticifolium* Bak. in Mart. Fl. Bras. vi. pt. 2, 343, t. 91 (1876); probably also Hieron. in Engl. Bot. Jahrb. xix. 45 (1894), not *E. urticaefolium* L. f. *Ooclinium Sideritis* DC. Prod. v. 134 (1836). *O. villosum* (Cass.) DC. l. c. *Haberlea divaricata* Pohl ex Bak. l. c., in syn. *Bembicium pilosum* Mart. ex Bak. l. c. 344, in syn.

Cauca: Popayan alt. 1500–2000 m., *Lehmann*, no. B. T. 1149 (Gr.).

Tolima?: in open thickets of savannahs near Dolores, alt. 1200–1600 m., *Lehmann* no. 7486, cited by Hieron. l. c. as *E. urticifolium*.

Without locality: *Humboldt & Bonpland* (Par., phot. Gr.).

[Venezuela, Guiana, Brazil.]

The name *E. pauciflorum* appears to be the oldest available of many which this somewhat variable yet always pretty readily recognizable species has borne, the name *urticaefolium* (arbitrarily altered to *urticifolium*) being inapplicable both because the type of Linnaeus filius, still in existence, has proved to be quite a different species and because the name is antedated by the valid homonym of Reichard now in use for a North American plant.

79. **E. kleinioides** HBK. Slender fibrous-rooted annual 1.5–6 dm. high, erect or ascending, with sparse spreading setose pubescence; leaves opposite, sessile, acute, subentire or remotely serrate, setose on both surfaces, the cauline linear or narrowly lanceolate, mostly

2–3 cm. long and 2–4 mm. wide, obscurely 3-ribbed, the basal spatulate-oblanceolate, sometimes as much as 8–12 mm. wide, more clearly 3-ribbed, narrowed to a petiole-like base; peduncles erect or ascending, 1-headed, 3–8(–15) cm. long; heads 12–14 mm. high, about 1 cm. in diameter, the disk at maturity strongly convex; involucre turbinate-subcylindric, about 3-seriate; inner scales lance-oblong, obtusish and often erose-marcescent at the tip, 3–5-nerved, the intermediate progressively shorter, acute to attenuate, the outermost linear to filiform, usually ciliate and often spreading at the attenuate apex; receptacle convex; corollas pale purple; achenes black, 5-ribbed but usually more or less compressed, hispid on the paler ribs or subglabrous.— Nov. Gen. et Spec. iv. 120 (1820); Bak. in Mart. Fl. Bras. vi. pt. 2, 342, t. 90, f. 1 (1876), where the range is extended to Colombia; Hieron. in Engl. Bot. Jahrb. xxii. 782–3 (1897), where also credited to Colombia. For extended synonymy see Bak. l. c.

COLOMBIA: *Humboldt & Bonpland*, and *Funck*, no. 223, acc. to Bak. l. c. [Venezuela to Paraguay and Peru.]

It is suspected that the particular specimens on the basis of which Baker ascribed this species to Colombia may have come from Venezuela, yet there is even in that event much likelihood that this weed-like annual widely distributed in South America occurs in Colombia.

Sect. V. CONOCLINIUM (DC.) Benth. Involucre campanulate; the scales acute, subequal or more often moderately graduated, mostly 2–4-seriate, persisting (except some of the innermost) after the fall of the achenes. Receptacle conical, naked.— Benth. ex Bak. in Mart. Fl. Bras. vi. pt. 2, 360 (1876); Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 140 (1890). *Conoclinium* DC. Prod. v. 135 (1836).— Herbaceous or suffruticose plants, chiefly perennial, rarely annual.

KEY TO SPECIES.

a. Leaves 3(–5)-nerved from slightly above the base *b.*
  b. Leaves (often alternate) mostly 2–5 cm. long, softly membranaceous; teeth rounded, (7–)9–14 on each side . 80. *E. ballotaefolium.*
  b. Leaves (opposite) very small, 4–15 mm. long (sometimes larger in no. 84, coriaceous; crenatures 3–5(–8) on each side *c.*
    c. Leaves covered above with rather coarse white hairs *d.*
      d. Flowering stems nearly naked and scapelike above the decumbent leafy base; leaves oval, rounded at base then somewhat cuneately narrowed to the petiole . . 81. *E. humile.*

d. Flowering stem leafy to above the middle; leaves triangular, the base truncate or nearly so........82. *E. pauperatum.*
c. Leaves glabrous above (or with obscure vestiges of arachnoid puberulence), white-woolly beneath *e.*
e. Leaves deltoid-ovate to suborbicular, rounded, truncate, or cordate at the base................83. *E. microphyllum.*
e. Leaves lance-ovate to lanceolate, acute at base...84. *E. lanulatum.*
a. Leaves pinnately veined *f.*
f. Leaves lanceolate, small, mostly 1–2 cm. long; lateral veins 4–6 on each side of the midrib....................84. *E. lanulatum.*
f. Leaves narrowly oblong, 3–6 cm. long; veins 12–18 on each side of the midrib.........................85. *E. stoechadifolium.*

80. **E. ballotaefolium** HBK. Weak branching herb or undershrub reaching 1 m. in height; stems flexuous, green, densely glandular-puberulent to -tomentellous; leaves opposite or (at least the upper) alternate, light-green, softly membranaceous (sometimes becoming stiffish in age), acute, subtruncate or shallowly cordate at base, 2.5–4 cm. long, three-fourths as wide, 3-5-nerved, softly pilose on both surfaces, paler beneath; petiole about 1.5 cm. long; heads 30–50-flowered, 5 mm. high, in small dense terminal corymbs disposed in a loosely and often irregularly branched open inflorescence; involucre campanulate, the scales about 30, acute; corollas lilac or blue (Pennell).— Nov. Gen. et Spec. iv. 121 (1820); Bak. in Mart. Fl. Bras. vi. pt. 2, 360 (1876); Klatt in Engl. Bot. Jahrb. viii. 34 (1887). *E. urticaefolium* L. f. Suppl. 354 (1781), not Reichard, nor Bak. *Conoclinium prasiifolium* DC. Prod. v. 135 (1836); Deless. Ic. iv. 6, t. 15 (1839). *E. nepetoides* Lindl. ex DC. l. c. in synon. *Conoclinium ballotaefolium* (HBK.) Sch. Bip. ex Bak. l. c. in synon. *E. ballotifolium* [HBK.] Ktze. Rev. Gen. i. 337 (1891); Heering, Mém. Soc. neuchât. Sci. Nat. v. 418 (1913).

CUNDINAMARCA: Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, no. 30 (U. S.); La Peña. alt. 2800 m., *Bros. Apollinaire & Arthur*, no. 46 (U. S.); dry meadow near Bogotá, alt. 2800–2900 m., *Pennell*, no. 2311 (Gr.).

ANTIOQUIA: San Cristobal, alt. 2800 m., *Bros. Apollinaire & Arthur*, no. 98 (Gr.); cultivated ground, Yarumito, *Mayor*, no. 569, acc. to Heering, l. c.

WITHOUT LOCALITY: *Mutis* (Linn. Soc., phot. Gr.); *Humboldt & Bonpland* (Par., phot. Gr.); *Otto*, no. 687 (Gr.); *Triana*, no. 1190 (K.).

[Venezuela, Margarita Island, Brazil.]

Variable, passing in Brazil into forms with smaller and more sharply toothed leaves. In Colombia the following varieties may be distinguished on involucral characters:

Var. **typicum**. Involucral scales lanceolate, moderately firm in texture and ribbed nearly or quite to the gradually narrowed tip, the outer successively shorter and narrower.— Lit., synon., and exsicc. as above.

Var. **caucense** Robinson. Involucral scales subequal, tending to be oblanceolate, the upper portion less gradually attenuate and of softer more herbaceous texture, scarcely ribbed and dorsally more pubescent.—Proc. Am. Acad. liv. 238 (1918). *E. ballotaefolium* Hieron. in Engl. Bot. Jahrb. xxviii. 575 (1901), not precisely of HBK.

Tolima: dry open grass-land, "El Convenio," west of San Lorenzo, alt. 1000–1200 m., *Pennell*, no. 3453 (Gr.).

Huila: common in scattered bushy places on savannahs, along the Rio Paez, *Lehmann*, no. 5675 (U. S.).

El Valle: under low isolated thickets, on savannahs near Anserma Nueva, alt. 1000 m., *Lehmann*, no. 3279 (Gr.).

While such variation in the involucre is unusual in a single species, it has been found impossible to detect any concomitant differences in habit, foliage, florets, or achenes. Furthermore some approaches to the involucre of var. *caucense* have been observed in the variable Brazilian forms of the species.

81. **E. humile** (Benth.) Robinson, comb. nov. Low perennial herb; stems several, hirsute, leafy at the prostrate and somewhat repent base, then erect, almost leafless and scapelike, 1.5–2 dm. high; leaves opposite, petiolate, oval, obtuse or rounded at both ends but at the very base somewhat cuneate, crenately about 3-toothed on each side, densely hirsute on both surfaces, 4–12 mm. long, 3–10 mm. wide; petiole 2–7 mm. long; corymb terminal, about 3–4 cm. in diameter, convex; pedicels spreading-hirsute; heads about 20-flowered, 5–6 mm. high, crowded; involucre campanulate, about 3-seriate; scales lanceolate, attenuate, very acute, thin-margined, 2–4-ribbed, at least the outer sparingly and rather coarsely pubescent on the back; receptacle, low-conical; corollas apparently whitish but perhaps blue, externally puberulent near the limb; achenes dark-gray, tapering to the callose base, rounded to the summit.— *Conoclinium humile* Benth. Pl. Hartw. 199 (1845).

Cundinamarca: in Cordillera de los Andes, near Bogotá, *Hartweg*, no. 1102 (N. Y., phot. Gr.)

Known as yet only from the original collection. The leaves are green on both surfaces, but are covered by coarse white attenuate mostly curved hairs. The prostrate portion of the stems has very short internodes and numerous leaves often proliferous in the axils, while the upright part bears only 2–3 pairs of remote somewhat reduced leaves.

82. **E. pauperatum** HBK. Pubescent, suffruticose, 3 dm. high, erect from a decumbent base, leafy two-thirds of the way to the small dense rounded terminal pedunculate corymb; leaves deltoid, acute, truncate at the base, crenate-serrate (teeth about 7 on each side, the proximal rounded, the distal acutish), 3-nerved, somewhat pubescent above, softly so beneath, 1.2 cm. long, 1 cm. wide; petiole about 6 mm. long; involucre campanulate; scales lanceolate, subulate-tipped, green, ribbed, ciliate, the slightly shorter outer ones dorsally pubescent; florets 5 mm. long; corollas glabrous, violet-tinged at the summit; achenes glabrous.— Nov. Gen. et Spec. iv. 121 (1820).

New Grenada? with no more definite locality, *Humboldt & Bonpland* (Par., phot. Gr.).

Known only from the original collection. Placed doubtfully in § *Conoclinium* from its resemblance to other members of the group. The writer has had no opportunity to ascertain the nature of the receptacle, a feature not mentioned in the original description.

83. **E. microphyllum** L. f. Small decumbent herb, 1–3 dm. high, perennial or at times fruticulose (but sometimes exhibiting fibrous apparently annual roots); stem terete, covered with fine spreading curved white hairs, leafy to the middle or somewhat higher; leaves opposite, petiolate, very small, thick, coriaceous, ovate, obtuse, rounded or more often cordate at base, crenately about 3-toothed on each side, 3-nerved, green and glabrous above, white-woolly on the under surface, 6–10 mm. long, 4–7 mm. wide; petiole 2–4 mm. long, hirsutulous; peduncular summit of the stem often 1 dm. long, flexuous, bearing 1–2 pairs of reduced leaves and a dense terminal rounded corymb (1.5–4 cm. in diameter); heads about 18-flowered; involucral scales 2–3-seriate, lanceolate, gradually attenuate to a subulate tip, green or often purple-tinged, 2–4-ribbed, the outer successively shorter, ciliate, pubescent on the back; corollas violet-tinged or blue (Rusby & Pennell), externally puberulent; achenes almost black, 2.3 mm. long, tapering downward, rounded at summit, glabrous.— Suppl. 355 (1781); Heering, Mém. Soc. neuchât. Sci. Nat. v. 419 (1913). *Conoclinium microphyllum* (L. f.) DC. Prod. v. 135 (1836).

Cundinamarca: Montserrate near Bogotá, *Holton*, no. 318 (Gr.); slopes of Montserrate and Páramo Cruz Verde, *Mayor*, no. 75, acc. to Heering, l. c.;

on highway to La Peña, *Stübel*, no. 102 (Berl., phot. and fragm. Gr.); Guadalupe, alt. 3000 m., *Bros. Apollinaire & Arthur*, no. 31 (Gr.); Bogotá, *Rusby & Pennell*, no. 1278 (N. Y.).

El Valle: La Paila, *Holton*, no. 250 (350) N. Y.

Without locality: *Mutis* (Linn. Soc., phot. Gr.); *Triana*, nos. 37 (Gr.) and 1169 in part (K.).

84. **E. lanulatum** Robinson. Low decumbent herbaceous or slightly woody plant, much branched and very leafy at least to the middle; root fibrous as if annual; stem terete, covered with a thin arachnoid flocculent wool; branches ascending, flexuous, ending in 1–3 dense rounded pedunculate corymbs; leaves opposite, petiolate, lanceolate, gradually narrowed to an obtusish tip, cuneate at the base, 1–1.5(–3) cm. long, 2–4(–10) mm. wide, with about 7 crenations on each side, glabrous or nearly so above, canescent-lanulate beneath; involucre and florets as in the preceding.— Proc. Am. Acad. liv. 249 (1918).

Cundinamarca: Guadalupe, alt. 2900 m., *Bros. Apollinaire & Arthur*, no. 33 (U. S., phot. and fragm. Gr.).

Without locality: *Triana*, no. 1169 in part (K.).

Obviously close to the preceding, yet readily distinguishable both by its very different leaf-contour and by its pubescence of exceedingly fine white wool, the individual hairs being obscure and implexed, not clearly spreading as in *E. microphyllum.*

85. **E. stoechadifolium** L. f. White-woolly perennial, herbaceous or distinctly shrubby, 8–15 dm. high; stems forking above; leaves opposite (or the upper alternate), narrowly oblong, tapering or rather abruptly rounded to an obtusish apex, cuneate to a short-petioled base, crenately many-toothed on each side, 3–6 cm. long, 4–10 mm. wide, pinnately many-veined from a strong midrib, grayish-puberulent above, white-woolly beneath; corymbs terminal on long erect almost leafless opposite or alternate branches; heads crowded, about 6 mm. high and 4 mm. in diameter, about 27-flowered; involucre campanulate, about 3-seriate, cottony at the base; scales lance-oblong, acuminate, green or toward the tip often dark-purple, at length somewhat tawny-stramineous; disk alveolate, at maturity more or less elevated; corollas lilac, blue, or white (Rusby & Pennell), the proper tube about equalling the gradually enlarged throat; achenes 1.8 mm. long, dark, glabrous except for traces of hispidity near the summit.— Suppl. 355 (1781); J. E. Sm. Ic. iii. t. 69 (1791); HBK. Nov. Gen. et Spec. iv. 116, t. 343 (1820).

CUNDINAMARCA: mountains near Bogotá, *Holton*, no. 322 (Gr.); *Rusby & Pennell*, nos. 1238 (N. Y.), 1308 (N. Y.), *Pennell*, no. 2324 (Gr.); Montserrate and plateau of Bogotá, [from the herb of] *de Parseval-Grandmaison*, no. 104 (Gr.).

WITHOUT LOCALITY: *Mutis* (Linn. Soc., phot. Gr.); *Humboldt & Bonpland* (sk. Gr.).

[Venezuela.]

Sect. VI. CAMPULOCLINIUM (DC.) Benth. Heads large 1–2 cm. high, many-flowered. Involucre campanulate; scales subequal, in about 2(–3) series, several–many-nerved or -striate rather than ribbed. Receptacle hemispherical to conical, glabrous, sometimes crowned by the persistent rudiments of abortive florets.— Benth. ex Bak. in Mart. Fl. Bras. vi. pt. 2, 354 (1876); Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 140 (1890). *Campuloclinium* DC. Prod. v. 136 (1836), in part. *Campyloclinium* [DC.] Endl. Gen. 369 (1838). *Campulochinium & Campylochinium* Hook. f. & Jacks. Ind. Kew. i. 409 (1893), by typographical errors.

KEY TO SPECIES.

Leaves ovate, rounded or cordate at base, slender-petioled.
  Leaves green on both surfaces, deeply cordate........86. *E. diplodictyon*.
  Leaves grayish-tomentose beneath, rounded at the base..87. *E. paezense*.
Leaves oblanceolate-oblong, narrowed to a subsessile base 88. *E. macrocephalum*.
Leaves ovate-elliptical or -lanceolate, sessile by a rounded base 89. *E. zinniifolium*.

86. **E. diplodictyon** Robinson. Presumably herbaceous; stem round, flexuous, dusky-tomentose, the hairs widely spreading and articulated; leaves opposite, triangular-ovate, long-acuminate, cordate with a deep narrow sinus, dentate, 7–10 cm. long, 4–6.5 cm. wide, 3–5(–7)-nerved, reticulate on both surfaces, bright green, shining and nearly glabrous above, green and pilose on the veins beneath; corymb terminal, long-peduncled, dusky-tomentellous with articulated hairs and stipitate glands; pedicels about 7 mm. long; heads 13 mm. high, about 30-flowered; involucral scales about 13, green, finely striate, sharply acuminate, spreading-pubescent on the back; receptacle bearing persistent vestiges of abortive florets at its elevated apex; corollas smooth, the proper tube exceeding the campanulate-cylindric throat; achenes olivaceous, shining, 2.8 mm. long.— Proc. Am. Acad. liv. 242 (1918).

COLOMBIA: without more precise locality, *Lobb* (K., phot. Gr.).

87. **E. paezense** Hieron. Suffruticose, much branched, light green, 2 m. high; stem terete, short-woolly; leaves opposite, petiolate, ovate, acute, rounded at the base, coarsely crenate to serrate, 7–8 cm. long, 3–4.5 cm. wide, membranaceous, 3(-5)-nerved; corymbs terminating the stem and curved-ascending branches, 5–12-headed; heads 1 cm. high, mostly about 125-flowered (florets varying from 60 to 140, acc. to Hieron.); involucral scales about 30, imbricated in 3–4 series, the outermost (1–3) lance-linear or narrowly lanceolate and bractlike, the intermediate very broadly ovate-oblong, acute to acuminate, multistriate and with a broad callosity at the base, covered dorsally with a fine and often glandular pubescence, the inner scales gradually narrower, the innermost linear; florets reddish-lilac, 4.5 mm. long, tubular, only slightly and gradually dilated toward the limb; achenes 2.8 mm. long, black, hispid on the angles.— Hieron. in Engl. Bot. Jahrb. xxviii. 574 (1901). *E. thespesiaefolium* Klatt in Engl. Bot. Jahrb. viii. 35 (1887), not in the least of DC.

HUILA: in woods on savannahs between La Plata and La Topa at the Rio Paez, alt. 1000–1500 m., *Lehmann*, no. 5672 (Berl., N. Y.).

EL VALLE: on talus about Narango at the Rio Dagua, alt. 600–800 m., *Lehmann*, no. CXII. (Gr.).

WITHOUT LOCALITY: *André*, no. 1592 (Gr.); *Triana*, no. 1171 (K.).

88. **E. macrocephalum** Less. Coarse erect or slightly decumbent perennial herb, 6–10 dm. high, setulose and scabrous; leaves opposite (or the upper alternate), subsessile, oblanceolate-oblong, crenate-serrate except at the narrowed base, 5–8 cm. long, 8–20 mm. wide, punctate and scabrously setose on both surfaces; branches of the terminal long-peduncled few-headed corymb fastigiate, unequal; heads erect, 1.2–1.5 cm. high, 1.8–2.5 cm. in diameter; scales subequal, lanceolate, acute, densely but shortly pubescent on the back; florets very numerous; corollas roseate, the long-exserted clavate style-branches conspicuous; achenes 5 mm. long, slender, slightly roughened on the ribs or quite glabrous, deeply sulcate between the angles.— Linnaea, v. 136 (1830); Bak. in Mart. Fl. Bras. vi. pt. 2, 358 (1876), which see for synonymy and varietal subdivision.

SANTANDER: boggy places near Velez, 11 Oct. 1845, *Purdie* (K.).

WITHOUT LOCALITY: 1846, *Purdie* (K.).

[Mexico, Brazil.]

89. **E. zinniifolium** Robinson. Shrub, covered with a short dense dark and gland-tipped tomentum, probably somewhat viscid

to the touch; branches terete, curved-ascending, leafy to the terminal corymbs; leaves opposite, closely sessile, ovate-oblong or elliptic-lanceolate, narrowed to an obtusish apex, serrate, sordid-pubescent on both surfaces, 5–7-nerved, about 7 cm. long, half as wide, rounded at the base; corymb umbelliform, about 10-headed; heads long-pedicelled, about 100-flowered, 12–13 mm. high; involucre campanulate; scales subequal, little imbricated, lance-oblong, acute, toward the base somewhat 2–4-nerved, dorsally pubescent and glandular, probably purplish-tinged; corollas rose-colored, the proper tube 2.6 mm. long, very slender, the throat 3.7 mm. long, campanulate-cylindrical, hispid on the outside toward the limb.— Proc. Am. Acad. liv. 261 (1918).

MAGDALENA: on the Sierra Nevada, Prov. of Rio Hacha, *Schlim*, no. 812 (K., phot. Gr.).

A species with conspicuous and somewhat massed heads of pink florets suggesting possible value in horticulture.

Sect. VII. HEBECLINIUM (DC.) Benth. Involucre 3-∞-seriate; scales graduated (the outer progressively shorter), persistent, usually acute. Receptacle strongly convex, ellipsoidal to hemispherical, hairy; the hairs (minute and obscure in the first species) usually conspicuous on the fall or removal of the achenes.— Benth. ex Bak. in Mart. Fl. Bras. vi. pt. 2, 345 (1876); Hoffm. in Engl. & Prantl, Nat. Pflanzenf. iv. Abt. 5, 140 (1890). *Hebeclinium* DC. Prod. v. 136 (1836).— A small and probably somewhat artificial section, ranging from Mexico to Brazil and Argentina.

KEY TO SPECIES.

Leaves on winged auriculate-based petioles; florets 200–300 90. *E. nemorosum*.
Petioles not winged
Florets about 20
Leaves densely white-silky beneath; corolla with a perceptibly enlarged throat about as long as the proper tube 91. *E. sericeum*.
Leaves subglabrous or sparingly pubescent on the veins beneath; corolla slender, uniformly tubular.......92. *E. erioclinium*.
Florets 50–75..................................93. *E. macrophyllum*.

90. **E. nemorosum** Klatt. Erect herb 0.6–2 m. high; stem terete, pithy, pubescent with both weak articulated and gland-tipped hairs; leaves (about 6 remote pairs) opposite, lanceolate or lance-

oblong, attenuate or acuminate, serrate except at the much contracted petiolar base, light-green, pubescent on both surfaces, pinnately veined, the expanded portion of the blade 7–15 cm. long, half as wide, the petiolar portion 2–7 cm. long, 3–12 mm. wide, somewhat dilated at the bi-auriculate and clasping base; heads numerous, paniculate, about 220-flowered, pedicellate, about 1 cm. high; involucre campanulate, about 3-seriate; the scales lanceolate, acute, not very strongly graduated; receptacle an oblate spheroid, slightly and at times rather obscurely puberulent; corollas slender-tubular, without distinct throat, white or greenish-yellow; achenes black, lucid, glabrous or nearly so.— Klatt in Engl. Bot. Jahrb. viii. 35 (1887); Hieron. xxix. 14 (1900), where affinity with § *Hebeclinium* was first indicated, and xxviii. 576 (1901); Robinson, Proc. Bost. Soc. Nat. Hist. xxxi. 251 (1904). *E. Rusbyi* Britton, Bull. Torr. Bot. Club, xviii. 334 (1891).

Cundinamarca: Arroya "Guayabetal," alt. 1300–1500 m., *Pennell*, no. 1750 (Gr.); dry cliff, "Susumuco," alt. 1400 m., *Pennell*, no. 1353 (Gr.).

Meta: moist bank, Villavicencio, alt. 500 m., *Pennell*, no. 1508 (Gr.).

El Valle: borders of woods and in clearings of thick moist woods, on the Cordillera Occidental, Calí, alt. 2000 m., *Lehmann*, no. 3777 (sk. and fragm. Gr.).

Cauca: in dense forests at the Rio Ortega, on the eastern slopes of the Cordillera Occidental, in the district of Popayan, alt. 1500–1700 m., *Lehmann*, no. 5964, acc. to Hieron., l. c.

[Costa Rica; Ecuador; Bolivia.]

A highly characteristic species, sometimes fibrous-rooted as if annual or at least flowering during the first season, but in other cases exhibiting a thickened and somewhat lignescent base as if perennial.

91. **E. sericeum** HBK. Tall vigorous perhaps climbing herb or more likely soft-wooded shrub; stem white-silky, terete or nearly so, flexuous; internodes elongated (often 1.5–2 dm. in length); branches widely spreading; leaves opposite, petiolate, ovate, caudate-acuminate, rounded at the base, serrate, 3-nerved from above the base, pale-green and shortly gray-silky above, canescent and silky-tomentose beneath, 7–15 dm. long, 4-10 cm. wide; petioles white-silky, about 3 cm. long; heads small, in ample panicles, about 20-flowered, about 5 mm. high; involucre campanulate; the scales regularly graduated, fusco-stramineous, obtusish to rounded at the tip; receptacle elevated, alveolate, densely woolly; corollas (doubtfully reported as violet) 3 mm. long, the proper tube slightly exceeding the

campanulate throat; achenes (immature) 1.3 mm. long; the ribs beset toward the summit with a few sessile glands.— Nov. Gen. et Spec. iv. 110 (1820); DC. Prod. v. 142 (1836). *Osmia sericea* (HBK.) Sch. Bip. Pollichia, xxii.-xxiv. 252 (1866).

WITHOUT LOCALITY: *Humboldt & Bonpland* (Par., phot. Gr.); *Triana*, no. 1173 (K.).

A striking species (with somewhat the habit of a *Mikania*) erroneously placed by DeCandolle in his § *Cylindrocephala*, and by Schultz, who perhaps knew the plant only from description, similarly referred to *Osmia*, from which of course it is clearly distinguishable both by its campanulate more loosely imbricated involucre and its hairy receptacle. It is unfortunate that the data of collection appear to have been lost on both occasions on which the plant has been secured.

92. **E. erioclinium** Robinson. Apparently herbaceous, erect, 12–15 dm. tall; stem round, tawny-tomentulose; leaves opposite, petiolate, suborbicular-ovate, acuminate, crenate-dentate to undulate or subentire, rounded or truncate or subcordate at the base, 1.2–2.6 dm. long, 10–22 cm. wide, membranaceous, subglabrous or somewhat tawny-tomentose on the nerves and veins, at the base pinnately veined, then palmately 3-nerved; petiole 3–8 cm. long; panicles ample, pyramidal, 2–3 dm. high and thick; heads about 20-flowered, subsessile in glomerules; involucre campanulate; scales about 16, ovate-oblong, unequal, obtuse; receptacle strongly convex, densely white-woolly; corollas white (Smith), tubular, without distinct throat, hispid at the summit; achenes glabrous or minutely hispid near the summit, 1.3 mm. long, black.— Proc. Am. Acad. liv. 243 (1918).

MAGDALENA: occasional in thickets near water, Las Nubes, near Santa Marta, alt. 1372 m., 15–20 Dec., *H. H. Smith*, no. 625 (Gr., U. S., Mo.); near Valparaiso, in ravines, alt. 1220–1525 m., *H. H. Smith*, no. 1995 (N. Y.).

93. **E. macrophyllum** L. Herbaceous or suffruticose, erect, tawny-tomentellous; stem terete; internodes long (often 1 dm. or more); leaves opposite, petiolate, broadly ovate, acuminate, broadly cordate with a short acumination at the insertion, crenate, membranaceous, gray-green and finely pubescent on both surfaces or sometimes velvety beneath; panicles terminal, dense, with spreading branches; heads 50–75-flowered, about 7 mm. high; involucre campanulate, many-seried, regularly graduated; scales lanceolate, acute or acutish, light-green with whitish ribs; corollas slenderly tubular, greenish- or yellowish-white or sometimes purplish- or bluish-lilac; achenes dark

gray, the white ribs slightly roughened near the summit.— Sp. Pl. ed. 2, ii. 1175 (1763); Bak. in Mart. Fl. Bras. vi. pt. 2, 345, t. 92 (1876); Hieron. in Engl. Bot. Jahrb. xxviii. 576 (1901); Heering, Mém. Soc. neuchât. Sci. Nat. v. 419 (1913). *Ageratum guianense* Aubl. Guian. ii. 800 (1775). *E. molle* Sw. Prod. 111 (1788). *Coleosanthus tiliaefolius* Cass. Bull. Soc. Philom. 1819, p. 157 (1819) & Dict. xxiv. 519 (1822). *Hebeclinium macrophyllum* (L.) DC. Prod. v. 136 (1836). *E. dryadeum* DC. Prod. vii. 269 (1838). *E. populifolium* Mart. Flora, 1837, pt. 2, Beibl. 105 (1837).

MAGDALENA: dry forest near Camp Alegre, alt. 458 m., *H. H. Smith*, no. 628 (N. Y.); near Santa Marta, alt. 762 m., *H. H. Smith*, no. 629 (Gr., U. S.).

HUILA: foot of the Cordillera Oriental, Neiva, *Rusby & Pennell*, no. 485 (N. Y.).

CALDAS: waysides between Filadelfia and Neira, alt. 1260 m., *Mayor*, no. 122, acc. to Heering, l. c.

EL VALLE: in bushy places near Las Juntas del Dagua, Prov. Calí, alt. 300–1000 m., *Lehmann*, no. 7696, acc. to Hieron., l. c.

[Widely distributed in tropical and subtropical America.]

III. KEYED RECENSIONS OF THE EUPATORIUMS OF VENEZUELA AND ECUADOR.

In the course of work primarily directed toward a revision of the Colombian Eupatoriums it was found needful to devote considerable attention to the identical or closely related species of Venezuela and Ecuador, and finally it has seemed desirable to list and key all the species of this genus known from those countries. As it appears likely that the matter thus assembled from very scattered sources will be found useful pending a monographic treatment of the whole group which cannot be completed for some years to come, it is here put on record.

EUPATORIUMS OF VENEZUELA.

Since Kunth, working upon the specimens secured by Humboldt & Bonpland, enumerated in 1820 five species of *Eupatorium* from Venezuela, there appears to have been no attempt to bring together, catalogue, key out, or otherwise to give any separate treatment for the Venezuelan members of this large genus. Although similar to Colombia in territorial extent and indeed comparable in its diversity of soil and variety of climatic conditions Venezuela is to our present knowledge much less rich in its flora, and in the case of *Eupatorium* has less than half as many species.

This difference, however, is probably more apparent than real, and it is to be remembered that of all the South American countries Venezuela has to date received the least botanical exploration. Indeed except for a few scattered and essentially coastal points which have been frequently visited, such as those around Caracas and La Guaira, Cumana and Carupano, Cumarebo and Porto Cabello, the only regions which appear to have had any serious botanical attention since the hurried journey of Humboldt and Bonpland more than a century ago have been the uplands of Mérida, visited by Moritz, Pittier, Jahn, Haman, and others, especially the region of Tovar, for some months the base of the indefatigable collector Fendler, the Paraguaná Peninsula, recently explored for its forestry resources by Curran & Haman, the islands of Margarita and Coche, diligently explored and carefully described by J. R. Johnston, and portions of the delta region of the Orinoco Valley, traversed by Rusby & Squires in their journey of 1896.

Of the species here enumerated, nearly all rest, as to their Venezuelan occurrence, upon specimens from definitely located places within the present limits of the country. However, a few (nos. 1, 7, 21, and 30), although examined in specimens said to have come from Venezuela, have either been unaccompanied by more definite locality, or have had place-names not capable of location by any of the maps or atlases available. Of no. 16 (*E. vitalbae*) no Venezuelan material has as yet been seen or reported, but the species is known so close to Venezuela and is so frequent on both sides of the country as to make its ultimate discovery within the limits of Venezuela almost certain.

In all these cases it has seemed best to err rather on the side of fullness than of critical elimination in drawing up the present list and therefore to include all species even somewhat vaguely recorded for Venezuela.

For a key to the sections of the genus reference may be made to p. 269.

Sect. I. CYLINDROCEPHALA DC. (see p. 270).

KEY TO SPECIES.

a. Leaves pointed (acutely or at least obtusely) at the base *b.*
  b. Pedicels sulcate-angulate, glabrous *c.*
    c. Leaves lanceolate, caudate-acuminate; involucre obtuse in bud *d.*
      d. Heads 45–75-flowered; leaves 3-nerved above the base 1. *E. pellium.*
      d. Heads 10–20-flowered; leaves definitely pinnate-veined.................................2. *E. Moritzianum.*
    c. Leaves ovate, obtusish to short-acuminate; involucre acute in bud...............................3. *E. laevigatum.*
  b. Pedicels terete or nearly so, pubescent or puberulent *e.*
    e. Involucral scales subherbaceous at tip *f.*
      f. Leaves lanceolate to narrowly oblong or linear; heads about 20-flowered...........................4. *E. ivaefolium.*
      f. Leaves rhombic-ovate; heads 45–60-flowered.....5. *E. urticoides.*
    e. Involucral scales often somewhat more deeply colored but in texture not much changed at tip *g.*
      g. Leaves strongly bullate above, narrowly lanceolate, attenuate to a subsessile base..................6. *E. meridense.*
      g. Leaves never strongly bullate above, ovate *h.*
        h. Scales rounded at the tip or slightly narrowed to an obtuse point *i.*
          i. Leaves usually 6–10 cm. long; veins not forming

an exserted network beneath; heads in compound corymbs *j*.

j. Leaves subchartaceous, subglabrous, ovate to ovate-lanceolate, attenuate, rather obscurely serrate (none in the least hastate); pedicels usually 1–1.5 cm. long, mostly curved or hooked . 7. *E. subscandens*.

j. Leaves membranaceous, somewhat thicker, rhombic- to deltoid-ovate, rather coarsely and often somewhat hastately crenate-toothed, densely and softly villous or even tomentose beneath; pedicels usually 2–8 mm. long, mostly straight . . . . 8. *E. odoratum*.

i. Leaves 2–5 cm. long; veins exserted and prominently reticulated beneath; heads in a leafy panicle . . . . 9. *E. squalidum*, v. *subvelutinum*.

h. Scales lance-linear, acute; heads in a leafy-bracted thyrsoid panicle; leaves small (2–4 cm. long), not conspicuously reticulated beneath 10. *E. oxylepis*, v. *caracasanum*.

a. Leaves cordate at base . . . . 11. *E. xestolepis*.

1. E. PELLIUM Klatt (see p. 272). VENEZUELA, without precise locality, *Funck & Schlim*, no. 522 (Gr.).

2. E. MORITZIANUM Sch. Bip. (see p. 273). MÉRIDA: in subalpine places, Mérida, *Moritz*, no. 1366 (Gr.).

3. E. LAEVIGATUM Lam. (see p. 273). FEDERAL DIST.: Caracas, *Birschel* (Gr., N. Y.).

4. E. IVAEFOLIUM L. (see p. 275). MÉRIDA: Tovar, *Fendler*, no. 1948 (Gr.).

5. E. URTICOIDES Sch. Bip. Nearly or quite herbaceous, 5 dm. high: stems round, branched above, sparingly beset with spreading jointed hairs; leaves opposite, rhombic-ovate, subchartaceous, coarsely serrate-dentate (the teeth sometimes again toothed), 6 cm. long, half as wide; panicles both terminal and from the upper axils, the ultimate cymes 3–7-headed; pedicels 7–18 mm. long; heads 45–60-flowered; involucre campanulate; scales 5–7-seriate, the inner long and narrow, scarious and with 1 green nerve, the apex subherbaceous, purplish and covered with orange glands, the outer scales gradually shorter, broader, and 3-striate, with subtriangular herbaceous appendages; corollas purple, 4.5 mm. long, glabrous; achenes (very immature) dark, the ribs stramineous and roughened.— Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xxviii. 568 (1901).— MÉRIDA: in warm places on the Victoriana road of Tovar, near La Viscaina, *Moritz*, no. 834, acc. to Hieron. l. c. FEDERAL DIST.: between La Guaira and Desaguados, near the city of Caracas, *Gollmer*, acc. to

Hieron. l. c. WITHOUT LOCALITY: *Lansberg*, acc. to Hieron. l. c. Not seen by the writer. The description compiled.

6. E. MERIDENSE Robinson. Herbaceous or somewhat shrubby perennial: stem erect, closely covered with short tawny wool of very fine matted hairs; internodes 3–6 cm. long; leaves opposite, lanceolate, attenuate-acuminate to each end, crenulate or subentire, firmish in texture, 4–6 cm. long, 1–1.5 cm. wide, bullate and puberulent above, tawny-tomentose on the 3 nerves and prominently reticulated veins beneath; corymb much rounded, compound, 1 dm. in diameter; heads numerous, pedicelled, about 10-flowered, 9 mm. high, 3.5 mm. in diameter; involucre slender-cylindric, 4–5-seriate; scales oblong, rounded or subtruncate at the ciliolate brownish summit; corollas presumably purple; achenes very slender, 3.2 mm. long or more, papillose on the ribs.— *E. scabrum* Sch. Bip. ex Hieron. in Engl. Bot. Jahrb. xxviii. 569 (1901), not L. f.— MÉRIDA: Mérida, *Moritz*, no. 1365 (Gr.).

7. E. ODORATUM L. (see p. 280). MÉRIDA: near Tovar, alt. 915 m., *Fendler*, no. 636 (Gr.), same locality, alt. 610 m., *Fendler*, no. 1949 (Gr.).

Var. PAUCIFLORUM Hieron. (see p. 281). MIRANDA: La Venta, *Wagener*, acc. to Hieron. in Engl. Bot. Jahrb. xxviii. 564 (1901). STATE NOT INDICATED: in bushy places at "Guajaca rumbo," alt. 600 m., *Wagener*, no. 277, acc. to Hieron. l. c.

8. E. SUBSCANDENS Hieron. (see p. 279). MÉRIDA: near Tovar, alt. 700 m., *Fendler*, nos. 1950 (Gr.) and 1950 β (Gr.).

9. E. SQUALIDUM DC. Shrub 1–2 m. in height, much branched above, densely pubescent; stems terete; branches ascending; leaves opposite, ovate, short-petioled, subcoriaceous, 2–5 cm. long, 1.5–3 cm. wide, 3-nerved from above the base, somewhat prominently reticulate-veiny beneath, puberulent above, slightly paler and more copiously sordid-pubescent beneath as well as closely beset with orange glands (appearing finally as a dark punctation); petiole 2–4 mm. long; inflorescence a leafy panicle; heads short-pedicelled, about 30-flowered, 8–10 mm. long, slender; involucre cylindric; scales firm, stramineous, somewhat browned toward the summit, closely imbricated in about 6 series, regularly graduated, rounded or usually somewhat narrowed to an obtuse apex, faintly 3-nerved, ciliolate; achenes slender, 3.5 mm. long, smooth or nearly so on the almost black faces, ciliolate on the light-colored ribs.— Prod. v. 142 (1836); Bak. in Mart. Fl. Bras. vi. pt. 2, 281 t. 77 (1876).

[Var. **typicum**. Stem hirsute-villous, the hairs spreading; leaves hirsute-villous beneath.— Common on plains in the interior of Brazil.]

Var. SUBVELUTINUM (DC.) Bak. Stem covered with a very fine incurved puberulence; leaves puberulent to sparingly tomentellous beneath.— Bak. l. c. 282.— MÉRIDA: near Tovar, *Fendler*, no. 1952 (Gr.).

Without adequate material to determine the extent to which the forms of this variable species are actually connected by intergradation, it has seemed best provisionally to accept Baker's disposition of the present plant as a variety of *E. squalidum*. It may be remarked that the leaves of the Fendler specimen are larger and more pointed than in any other material of *E. squalidum* seen by the writer, but concomitant differences of significance have not been observed.

10. E. OXYLEPIS DC. Shrubby, 1–2 m. high, much branched, scented; branches ascending, terete, somewhat woody, grayish-pubescent; leaves opposite, elliptic-ovate to ovate-lanceolate, subentire to crenate-serrate (often with a single tooth or sometimes with 2–4 teeth on each side), slightly roughened above, velvety-hirsute beneath, 2.8 cm. long, 1.6 cm. wide, 3-nerved from the base; petiole 2–4 mm. long; panicle much branched, very leafy; heads 14–20-flowered, 7–10 mm. high; involucre cylindrical, acute in bud; scales stramineous, firm, regularly graduated in 5–7 series, closely appressed, glabrous, slightly lucid, lanceolate to lance-linear, gradually narrowed to a really acute or (especially in the case of the outer) somewhat darkened and obtuse actual tip; corollas purple, cylindrical, glabrous. — Prod. v. 145 (1836); Bak. in Mart. Fl. Bras. vi. pt. 2, 284 (1876), excl. syn. *E. pungens* Gardn.

[Var. **typicum**. Heads about 1 cm. long; corollas 4–5 mm. long; achenes 3–4 mm. long.— Plains of Brazil, in provinces of Goyaz, Minas Geraës, São Paulo, etc.]

Var. CARACASANUM (Sch. Bip.) Hieron. Closely similar in habit, foliage, pubescence, etc.: heads somewhat smaller; involucre about 7 mm. long; corollas and achenes proportionally shorter.— Hieron. in Engl. Bot. Jahrb. xxviii. 567 (1901), as *caracasana*. *E. caracasanum* Sch. Bip. ex Hieron. l. c.— FEDERAL DIST.: Caracas, *Birschel* (Gr.), *Moritz*, no. 65, acc. to Hieron. l. c. MÉRIDA: on stony hills near Incantados de Petare, *Gollmer*, acc. to Hieron. l. c. MÉRIDA: near Tovar, alt. 671 m., *Fendler*, no. 1951 (Gr.), identified with the type material at the Royal Botanical Museum in Berlin by Dr. J. M. Greenman.

11. E. XESTOLEPIS Robinson (see p. 261). Stems round, woolly when young, almost smooth in age, dusky, pithy; branches widely spreading, curved (either upward or downward), sordidly and densely

woolly-villous; leaves opposite, ovate, sharply acuminate, cordate at the rounded base, crenate-serrate, 3–5 cm. long, 2–3 cm. wide, bullate and puberulent above, below gray-tomentose and prominently reticulated with transverse veins between the 3(–7) nerves; corymbs open and few-headed; pedicels spreading, slender, pubescent, 2–12 mm. long; heads about 9 mm. high, 6 mm. in diameter, about 28-flowered; involucre campanulate-subcylindric, the scales about 27, somewhat rigid, ivory-white, shining, 1–3-nerved, 4–5-seriate, promptly deciduous; corollas glabrous, 4 mm. long, the proper tube considerably exceeding the campanulate throat; pappus-bristles about 26, slightly clavellate and yellowish toward the top; achenes black, 4–5-angled, slightly scabrid on the angles.— MÉRIDA: near Tovar, *Fendler*, no. 638 (Gr.). FEDERAL DIST.: Caracas, *Birschel* (Gr.); on the old road from Caracas to La Guaira, alt. 1100–1700 m. *Pittier*, no. 5880 (U. S., N. Y.).

Sect. II. SUBIMBRICATA (DC.) Hoffm. (see p. 281).

KEY TO SPECIES.

- *a*. Perennial herbs or shrubs *b*.
  - *b*. Heads separate or in small (2–5-headed) glomerules, disposed in open panicles *c*.
    - *c*. Involucral scales 2–3(–5)-nerved or -ribbed *d*.
      - *d*. Leaves pinnately veined *e*.
        - *e*. Heads about 13-flowered; leaves attenuate at base, about 3 cm. wide; corolla with a perceptibly enlarged throat about as long as the proper tube . . 12. *E. tovarense*.
        - *e*. Heads about 21-flowered; cauline leaves mostly rounded at base, 4.5–10 cm. wide; corolla without differentiated throat . . . . 13. *E. Squiresii*.
      - *d*. Leaves palmately 3(–5)-nerved *f*.
        - *f*. Heads about 5-flowered *g*.
          - *g*. Leaves crisped-puberulent to tomentose but not glandular beneath . . . . 14. *E. iresinoides*.
          - *g*. Leaves copiously glandular-pubescent beneath 15. *E. Wageneri*.
        - *f*. Heads 20–25-flowered . . . . 22. *E. pycnocephalum*.
    - *c*. Involucral scales multiseriate; heads 1.2–1.6 cm. high 16. *E. vitalbae*.
  - *b*. Heads in flattish-topped fastigiately branched cymose panicles; leaves firm-coriaceous . . . . 17. *E. amygdalinum*.
  - *b*. Heads crowded in corymbose or thyrsoid panicles *h*.
    - *h*. Leaves lanceolate to rhombic-ovate, attenuate to an essentially sessile base . . . . 18. *E. inulaefolium*.
    - *h*. Leaves ovate-oblong to suborbicular, mostly rounded or obtuse at the distinctly petioled base *i*.
      - *i*. Shrubs (except *E. tenuifolium*); heads 4–10-flowered *j*.

j. Leaves thickish and velvety or firm and subcoriaceous *k.*
  k. Heads in thyrsoid panicles; scales rounded or obtuse at the somewhat narrowed tip; stem glabrate 19. *E. morifolium.*
  k. Heads in a corymbosely branched flattish-topped panicle; scales acute; stem tomentose. . .20. *E. Vargasianum.*
j. Leaves thin and delicate, glabrous, rhombic-ovate 21. *E. tenuifolium.*
i. Herbaceous perennial; heads 20–25-flowered. .22. *E. pycnocephalum.*
a. Annual; leaves thin, ovate; heads small, in an open panicle 23. *E. microstemon.*

12. E. TOVARENSE Robinson (see p. 259). Branches slender, virgate, leafy, sordidly puberulent; leaves opposite, short-stalked, lance-oblong, attenuate-acuminate, cuneate at the base, feather-veined, 7–11 cm. long, 2.8–3.3 cm. wide, remotely and obscurely cuspidate-denticulate, membranaceous, green on both surfaces, glabrous above, puberulent on the veins and atomiferous beneath; petiole about 1 cm. long; panicle divaricately branched, leafy-bracted, puberulent, its branches naked toward the base; pedicels 1–3 mm. long; heads about 13-flowered, 6 mm. high, 3.5 mm. in diameter; involucre campanulate; scales about 21, stramineous-scarious, 3–4-seriate, dorsally puberulent toward the rounded tip, mostly 3-nerved and 2–4-ribbed; corollas 3 mm. long, microscopically granulate on the outside of the limb, the proper tube about equalling the slightly but distinctly enlarged throat; achenes 1.5 mm. long, black, slightly papillose on the angles; pappus-bristles about 36, white, delicately capillary.— MÉRIDA: near Tovar, alt. 1200 m., *Fendler*, no. 1947 (Gr.).

13. E. SQUIRESII Rusby (see p. 258). Tall perennial herb or virgate-branched shrub; stem smooth, green; leaves opposite, short-petioled, oblong, narrowed to both ends, short-acuminate at apex, usually rounded at base but sometimes slightly decurrent on the petiole, repand-dentate, feather-veined, membranaceous, green on both surfaces, glabrous throughout or sordid-puberulent on the midrib and veins beneath, 9–22 cm. long, about half as wide; panicle large, terminal, leafy-bracted to the middle, as much as 3 dm. long and 2 dm. in diameter, its branches divaricate, some bearing heads (on short secondary branchlets) almost or quite from the base; heads about 22-flowered, 6 mm. high; involucre pale straw-colored and scarious; scales in 3–4 series, graduated, dorsally somewhat pubescent toward the rounded apex; corollas yellowish-white; achenes black, 1.3 mm. long.— DELTA AMACURO: Paloma, *Rusby & Squires*, no. 2 (N. Y., Gr.).

14. E. IRESINOIDES HBK. (see p. 285).

Var. *α.* VILLOSUM Steetz. Leaves copiously villous to tomentose beneath; scales of the involucre acute to acuminate.— Steetz in Seem. Bot. Herald, 145 (1854).— MÉRIDA: Tovar, *Moritz,* no. 1722, *Fendler,* nos. 624 (Gr.), 1946 (Gr.). FEDERAL DIST.: Caracas and La Guaira, *Moritz,* acc. to Steetz, l. c. ARAGUA: Las Adjuntas, *Eggers,* no. 13,346 (U. S.). MARGARITA ISL.: El Valle, *Miller & Johnston,* no. 129 (Gr.); San Juan Mountain, *Johnston,* no. 95 (Gr.).

Var. *β.* GLABRESCENS Steetz. Leaves sparingly villous or nearly smooth; scales of the involucre acute or acuminate.— Steetz in Seem. Bot. Herald, 145 (1854).— FEDERAL DIST.: on mountains and in mountain gorges, in moist shady places among Agaves, La Guaira, *Otto,* no. 383 (Gr.); also *Moritz,* acc. to Steetz, l. c. CARABOBO: Puerto Cabello, *Curran & Haman,* no. 1153 (Gr.).

Var. *γ.* BREVIFLORUM Hieron. Stems whitish-tomentellous; leaves deltoid-ovate, conspicuously and cuneately decurrent upon the petioles; heads slightly smaller; involucre about 4 mm. long, the scales broader, the inner and middle obtuse, the outermost acutish.— Hieron. in Engl. Bot. Jahrb. xxviii. 573 (1901), as *breviflora.*— MÉRIDA: near Tovar, *Fendler,* nos. 623 (Gr.), 1946 (Gr.). FEDERAL DIST.: Caracas, *Birschel.* The type of this well marked variety was a plant cultivated in the Royal Garden at Berlin, about 1843 (phot. Gr.).

15. E. WAGENERI Hieron. Doubtfully shrubby; branches slightly sulcate-angled or subterete, velvety; internodes as much as 4.5 cm. long; leaves opposite, petiolate, broadly deltoid-ovate, shortly acuminate to an acutish or obtusish point, entire or undulate, cuneate and decurrent on the petiole, membranaceous, glandular-puberulent above, densely glandular-pubescent beneath, 3-nerved well above the base, as much as 4.5 cm. long and 3 cm. wide; panicle terminal; heads 5-flowered, cymosely glomerate, sessile or very shortly pedicelled; involucre turbinate-cylindric; scales about 12, scarious, dark-stramineous, ciliolate toward the obtusish but spinulose-mucronate tip; the inner about 4 mm. long, the outer gradually shorter; corolla (in dried state) yellowish, 2.5 mm. long, the proper tube scarcely more than 0.75 mm. long, the throat funnel-formed, 1.25 mm. long; style-branches scarcely thickened; pappus-bristles yellowish-white, connate into an annulus at the base; achenes 1.5 mm. long, the concolorous ribs roughened, the faces scabrid-pilose.— Hieron. in Engl. Bot. Jahrb. xl. 375 (1908).— VENEZUELA: without locality, *Wagener,* no. 178, acc. to Hieron. l. c. Not seen by the writer, the description compiled.

16. E. VITALBAE DC. (see p. 299). A species of frequent occurrence and wide distribution in the warmer parts of America, but not yet reported from Venezuela. However, as it is known to occur in Colombia, to the west, Dutch Guiana to the east, and Brazil, to the south, its ultimate discovery in this as yet very slightly explored country, seems highly probable.

17. E. AMYGDALINUM Lam. (see p. 301). VENEZUELA: without locality, *Moritz*, no. "6(80)" (Gr.). MÉRIDA: near Tovar, *Fendler*, no. 654 (Gr.). FEDERAL DIST.: Galipan near Caracas, *Kuntze*, no. 1525b (N. Y.).

A very sketchy subdivision of this species has been attempted by Kuntze, Rev. Gen. i. 337 (1891). Quite without detailed statement of differential characters, ranges, previous literature, or of critically determined exsiccatae the treatment is of little value. The subdivisions are based on characters which are confessedly subject to independent variation, their combinations being numerous and inconstant, so that they have almost no classificatory value. Finally to make the matter worse, even the rank of the proposed subcategories is in several cases left wholly obscure.

18. E. INULAEFOLIUM HBK., forma TYPICUM (see p. 292). Widely distributed from Colombia to Brazil, and with scarcely a doubt to be found in Venezuela.

Forma SUAVEOLENS (HBK.) Hieron. (see p. 292). MÉRIDA: near Tovar, *Fendler*, no. 641 (Gr.).

19. E. VARGASIANUM DC. (see p. 289). BERMUDEZ: Aragua, *Cruger* (K.) FEDERAL DIST.: Caracas, *Vargas* (DC., phot. Gr.), *Linden*, no. 137 (K.). MÉRIDA: near Tovar, *Fendler*, no. 647 (Gr.).

20. E. MORIFOLIUM Mill. (see p. 293). MÉRIDA: near Tovar, *Fendler*, no. 646 (Gr.).

To this species may be provisionally referred *Critonia heteroneura* Ernst, Flora, lvii. 210 (1874). FEDERAL DIST.: on Mt. Galipan near Caracas, *Ernst*. No material authentically representing Ernst's species has been seen, yet his description is careful and so detailed that it is possible to check up the many points in which his plant agrees fully with *E. morifolium*. It is true the florets are said to be only four, while in *E. morifolium* they are often considerably more numerous, but the number appears to be quite variable even in specimens obviously otherwise identical. The peculiar nervation, on which Ernst laid stress as a differential character and which suggested the name he chose for his plant, can be accurately matched even in specimens from Vera Cruz, the type-region of *E. morifolium*.

21. E. MACROPHYLLOIDES Robinson (see p. 249). Tall soft-wooded shrub 3–4 m. high; stems round, tawny-woolly; leaves opposite, triangular-ovate, acute or acuminate, subtruncate at base but shallowly cordate at the point of insertion, crenulate practically from the base, about 1 dm. long and 8 cm. wide, membranaceous, soft in texture, 3-nerved (the lateral nerves bearing on the outer side several branches almost from the base), dusty-puberulent above, grayish and softly pubescent beneath; petioles as much as 6 cm. long; inflorescence a trifid compound corymb, the parts dense, rounded, many-headed; heads short-pedicelled, about 11-flowered; involucre subcylindrical, rather loosely imbricated; scales about 4-seriate, thin, straw-colored, the inner oblong-linear, rounded at the apex, the outer gradually shorter, obtuse, ciliolate; corolla probably whitish, 4 mm. long; the slender proper tube about as long as the perceptibly and gradually enlarged throat; style-branches filiform; achenes 2 mm. long, hispid; pappus-bristles about 36, unequal.— VENEZUELA (state not indicated): at "Sanchorquig," *Eggers,* no. 13,413 (U. S.).

22. E. TENUIFOLIUM HBK. Herbaceous perennial; stem slightly angled, branching toward the top and leafy almost to the summit; internodes as much as 7 cm. long; leaves opposite, slender-petioled, rhombic-ovate, acute, sharply dentate except at the cuneately contracted base, 3-nerved, membranaceous, thin, 6–7 cm. long, 3–4.5 cm. wide, glabrous above, pubescent on the nerves and veins beneath; heads about 7-flowered, sessile in dense subglobose glomerules; involucre cylindrical; scales about 14, very unequal, the inner linear-oblong, obtuse or rounded at the tip, subglabrous, the outer gradually shorter, ovate, ciliate, subacute.— Nov. Gen. et Spec. iv. 107 (1820).— BERMUDEZ: between Bordones and Cumana, *Humboldt & Bonpland* (Par., phot. and trac. Gr.).

23. E. PYCNOCEPHALUM Less. (see p. 296). MÉRIDA: near Tovar, *Fendler,* no. 1953 (Gr.). A form somewhat more pubescent than the nearly smooth Mexican type, but without other differences of moment.

24. E. MICROSTEMON Cass. (see p. 295). *E. microstemon, α. albiflorum* Ktze. Rev. Gen. i. 338 (1891). MÉRIDA: near Tovar, *Fendler,* nos. 648 (Gr.), 1943 (Gr.). VENEZUELA, without locality, acc. to Kuntze, l. c.

Var. LILACINUM Ktze. Florets lilac.— Rev. Gen. i. 338 (1891).— MÉRIDA; near Tovar, *Fendler,* no. 649β (Gr.).

Sect. III. EXIMBRICATA (DC.) Hoffm. (see p. 303).

KEY TO SPECIES.

a. Leaves 3(–5)-nerved from or slightly above the base b.
  b. Heads 10–15-flowered, panicled ....25. *E. solidaginoides.*
  b. Heads 20–∞-flowered, corymbed c.
    c. Villous, the hairs rather long, slender, clearly articulated; herbaceous or suffruticose d.
      d. Creeping; rhizome filiform; stems several; leaves about 1.8 cm. long and 1.3 cm. wide ....26. *E. sillense.*
      d. Not creeping; leaves 5–7 cm. long, 4–5 cm. wide e.
        e. Leaves coarsely and crenately 7–10-toothed on each side ....27. *E. articulatum.*
        e. Leaves serrately or crenately 12–18-toothed on each side ....28. *E. ibaguense.*
    c. Puberulent, the hairs very short, not articulated or very obscurely so ....28a. E. n. sp.?
a. Leaves pinnate-veined, oblong or elliptical, coriaceous; shrubs, often viscid on the involucre g.
  g. Heads about 6-flowered; leaves 6–9.5 cm. long, woolly on the midrib beneath ....29. *E. Jahnii.*
  g. Heads 10–15-flowered; leaves 2–3.5 cm. long h.
    h. Leaves elliptical, the exserted veinlets beneath not sulcate; pubescence of spreading attenuate bristles ...30. *E. flavisetum.*
    h. Leaves oblong, the exserted veinlets beneath sulcate; pubescence scanty, of short incurved hairs ....31. *E. theaefolium.*

25. E. SOLIDAGINOIDES HBK. (see p. 310). MÉRIDA: near Tovar, alt. 1067 m., *Fendler,* no. 629 (Gr.).

26. E. SILLENSE Hieron. Creeping by means of threadlike rhizomes; stems several, as much as 4 dm. high, sparingly villous, the hairs articulated; internodes sometimes as much as 5 cm. long; leaves opposite, petiolate, ovate, short-acuminate, crenate except at the rounded or cordate base, membranaceous, green and slightly glaucous on both surfaces, villous especially on the nerves, the largest 1.8 cm. long, 1.3 cm. broad; petiole scarcely over 1 cm. long; heads rather loosely cymose-corymbed at the top of the stem, 20–25-flowered; pedicels as much as 8 mm. long; involucre campanulate, the scales 12–14, linear, obtusish, nearly equal, 4.5 mm. long, thin, scarious and somewhat stramineous, villous-ciliate, 3-nerved; corollas about 3.25 mm. long, yellowish-white (in dried state); the proper tube about equalling the campanulate throat.— Hieron. in Engl. Bot. Jahrb. xl. 382 (1908).— FEDERAL DIST.: on Mt. Silla de Caracas, 20 January, 1856, *Gollmer,* without number. Not seen by the writer; said to resemble *E. caducisetum* DC. and *E. glechonophyllum* Less. Description compiled.

27. E. ARTICULATUM Sch. Bip. (see p. 316). MÉRIDA: in grassy places on the Sierra de Mérida, *Moritz*, nos. 1371 and 1410, acc. to Hieron, l. c. 385.

28. E. IBAGUENSE Sch. Bip. (see p. 317). MÉRIDA: near Tovar, *Fendler*, nos. 642 (Gr.), 643 (Gr.). FEDERAL DIST.: Caracas, *Moritz*, no. 252 (sk. and fragm. Gr.).

28a. E. n. sp.? At this point in keying the available material of the Venezuelan Eupatoriums is to be placed a doubtfully distinct plant represented from Tovar by Fendler's nos 649 and 650, both being in the Gray Herbarium. In nearly all technical characters close to the preceding, this plant differs in being smoother. The whole plant, in the two specimens seen, is strongly nigrescent in drying. The stem, with arched-ascending opposite branches, becomes smooth and strongly lignified toward the base. Although the plant is probably undescribed, it seems best pending further knowledge of its near reatives to leave it unnamed, especially as the material is too young to show the flowers in full anthesis.

29. E. JAHNII Robinson (see p. 248). Shrub; stems stout, jointed, virgate, leafy, terete, dark-purple, at first sparingly sordid-woolly, soon glabrate; internodes 2–3 cm. long; leaves oblong, acute or acutish at both ends, serrate-dentate, pinnately veined (about 10 veins on each side of the midrib), coriaceous, 6–9.5 cm. long, 2.3–4 cm. wide, above subglabrous and slightly lucid, the midrib somewhat woolly-villous, beneath sordid- or tawny-villous or woolly on the midrib and chief veins; petiole about 8 mm. long; corymb terminal, flattish or moderately convex, 7–9 cm. in diameter, crowded, many-headed, its branches and pedicels purplish-brown, pubescent; heads about 6-flowered, about 11 mm. high and 4 mm. in diameter; involucre subcylindric-campanulate, often viscid, the scales about 11, about 2-seriate, loosely imbricated but unequal, thickish except on the edges, dorsally convex, puberulent and somewhat glandular; corolla (probably purplish but in dried state pale brownish-yellow) 6 mm. long, glabrous, the proper tube much exceeded by the subcylindrical perceptibly enlarged throat; achenes 3.5 mm. long, very shortly hispidulous on the angles; pappus-bristles about 37, yellowish-white, stiffish, unequal.— MÉRIDA: Sierra de Mérida (Rio de Nuestra Señora), alt. 3000–4000 m., 16 January, 1910, *Dr. Alfredo Jahn*, no. 80 (U. S., phot. Gr.).

30. E. FLAVISETUM Robinson (see p. 244). Shrub with round ascending jointed branches; branchlets leafy, at first densely covered with yellowish or tawny spreading short but attenuate often curved

bristles; leaves opposite, elliptical, obtuse or rounded at both ends, crenate-serrate, coriaceous, 3–3.5 cm. long, 1.3–2 cm. wide, finely reticulated on both surfaces (the veinlets exserted but not sulcate), sparingly setulose above, more copiously setose chiefly on the midrib and larger veins beneath; petioles 1–3 mm. long; corymbs small, dense, terminal, 2–3 cm. in diameter; pedicels short, stout, shaggy with yellowish bristles; involucre campanulate, pubescent; scales about 20, of firm texture, lanceolate, loosely imbricated in about 2 series, ciliolate, often darker toward the tip; corollas glabrous, 5.5. mm. long; the proper tube 2 mm. long, the perceptibly enlarged throat campanulate-subcylindrical, 3 mm. long; anthers rounded at base, the apical appendage blunt or retuse; achenes 3.5 mm. long, hispidulous especially on the angles.— "VENEZUELA, &c." coll. of 1842–3, *Funcke*, no. 520 (K., phot. Gr.).

31. E. THEAEFOLIUM Benth. (see p. 309). VENEZUELA: without locality, *Linden*, no. 464 (Gr.). TRUJILLO: Páramo de Jabón, alt. 3000–3200 m., *Jahn*, no. 29 (U. S.).

Sect. IV. PRAXELIS (Cass.) Benth. (see p. 318).

32. E. PAUCIFLORUM HBK. (see p. 319). *E. urticifolium* Bak. in Mart. Fl. Bras. vi. pt. 2, 343 (1876), t. 91, not *E. urticaefolium* L. f.— MÉRIDA: near Tovar, alt. 610 m., *Fendler*, no. 1955 (Gr.).

Sect. V. CONOCLINIUM (DC.) Benth. (see p. 320).

Leaves ovate, 3-nerved, green beneath................34. *E. ballotaefolium*.
Leaves narrowly oblong, pinnately many-veined, white beneath.
35. *E. stoechadifolium*.

33. E. BALLOTAEFOLIUM HBK. (see p. 321). *E. ballotifolium* [HBK.] Ktze. Rev. Gen. i. 337 (1891).— MÉRIDA: near Tovar, alt. 1067 m., *Fendler*, no. 653 (Gr.). FEDERAL DISTRICT: around Caracas, alt. 800–1200 m., *Pittier*, no. 5869 (N. Y.); La Guaira to Caracas, *Kuntze*, no. 1244 (N. Y.); Coticita, *Curran & Haman*, no. 1065 (Gr.); between La Guaira and Rio Grande, *Curran & Haman*, no. 1032 (Gr.); La Guaira, *Robinson & Lyon*, acc. to Johnston, Proc. Bost. Soc. Nat. Hist. xxxiv. 267 (1909). STATE NOT CLEAR: Quebreda de Anoisco, *Eggers*, no. 13,108 (U. S.). MARGARITA ISL.: El Valle, *Miller & Johnston*, no. 234 (Gr.); San Juan Mountain, alt. 500 m., *Johnston*, no. 95 (Gr.).

34. E. STOECHADIFOLIUM L. f. (see p. 324). MÉRIDA: Páramo de Mucuchies, *Moritz*, no. 1409 (Gr.).

Sect. VI. Hebeclinium (DC.) Benth. (see p. 327).

35. E. macrophyllum L. (see p. 329). Mérida: near Tovar, alt. 915 m., *Fendler*, no. 644 (Gr.).

Excluded Species.

It has been impossible to ascertain upon just what material "*E. heptanthum* Sch. Bip." was reported by Rusby, Bull. N. Y. Bot. Gard. iv. 378 (1907) from Venezuela where "apparently collected by Seemann." From Rusby's description, however, and from Bolivian material referred by him to *E. heptanthum* it has become entirely clear that he applied the name to a plant wholly distinct from the one so named and described by Weddell, Chlor. And. i. 217 (1857).

For *E. azangaroense* Sch. Bip. the following station, which might be inferred to have been Venezuelan, is given by Weddell, Chlor. And. i. 217 (1857): "Caracas: dans la Sierra-Nevada de Santa Marta!, h. 2600 m. (Funck, *exsicc.* no. 391)". However, from the sequence of Funck's numbers mentioned elsewhere in the same work it appears clear that the Sierra-Nevada de Santa Marta mentioned here was the well known one in Colombia.

EUPATORIUMS OF ECUADOR.

The most complete previous treatments of the Ecuadorian Eupatoriums have been those of Jameson, Syn. Pl. Aeq. ii. 79–90 (1865), and of Hieronymus in Engl. Bot. Jahrb. xxix. 5–15 (1900). In these, Jameson described 1 species of *Hebeclinium,* which he maintained as a separate genus, and 25 species of *Eupatorium,* while Hieronymus, enumerating only such plants as were contained in the extensive collections of the late Prof. A. Sodiro, listed 31 species and 2 varieties of *Eupatorium,* giving many helpful notes regarding the older species as well as diagnoses of several newly recognized members of the group. In neither of these treatments was there any attempt to key the plants.

In comparing the Eupatoriums of Ecuador with those of Colombia one is struck by the considerably altered proportions of the sections. Thus of the common and widely distributed Sect. *Cylindrocephala,* represented in Colombia by no less than 20 species and several well marked varieties, there are in Ecuador only 4 species. The two small sections, *Praxelis* and *Campuloclinium*, represented in Colombia, are as yet unrecorded in Ecuador. Of Sect. *Conoclinium*, with 6 chiefly endemic species in Colombia, there are but 2 species in Ecuador. On the other hand, Sect. *Hebeclinium*, with but 4 species in Colombia, has no less than 6 species in the much smaller area as yet botanically explored in Ecuador. By far the greater part of the Ecuadorian Eupatoriums fall into Sect. *Subimbricata* and Sect. *Eximbricata*. These sections are about equally represented and in Ecuador as elsewhere they are quite confluent, their separation, although convenient and almost necessary for purposes of classification, being manifestly artificial.

The absence from Ecuador of certain species known to occur both in Colombia and Peru may well be due to imperfect exploration. In this connection it is to be remembered that botanical investigation of the country has as yet been restricted to limited and relatively accessible areas, but that the country as a whole presents such remarkable diversity in altitude, temperature, precipitation, exposure, and soil-conditions that when more fully explored, especially when the large and little known Prov. Oriente has been investigated, it can scarcely fail to yield an exceedingly rich flora greatly extending the representation of this as well as other large genera.

Of species pretty certain to be found in Ecuador *E. amygdalinum* Lam., *E. pauciflorum* HBK., and *E. macrophyllum* L. may be mentioned with a fair degree of confidence.

For a key to the sections of the genus, see p. 269.

Sect. I. CYLINDROCEPHALA DC. (see p. 270).

KEY TO SPECIES.

a. Leaves ovate or lanceolate, long-acuminate or gradually narrowed to the apex *b*.

b. Petiole one sixteenth to one eighth the length of the leaf-blade; heads 7–8(–10)-flowered, very slender, acute or acutish in bud .... 1. *E. leptocephalum*.

b. Petiole at least one-fifth as long as the blade; heads 10–35-flowered, obtuse or obtusish in bud .... 2. *E. odoratum*.

a. Leaves oval or elliptical, merely acutish to short-acuminate *c*.

c. Heads in flattish or moderately convex corymbs; involucral scales viscid, scarcely or not at all ciliate .... 3. *E. laevigatum*.

c. Heads subsessile in panicled glomerules; involucral scales conspicuously ciliate, not noticeably viscid .... 4. *E. Eggersii*.

1. E. LEPTOCEPHALUM DC. (see p. 278). To this species the writer would refer *E. tequendamense*, vars. *glanduloso-pubescens* and *glabrata* Hieron. in Engl. Bot. Jahrb. xxix. 6 (1900). Examined in fragments kindly supplied to the Gray Herbarium some years ago by the management of the Royal Botanical Garden at Berlin, these varieties are found to differ but slightly and in degree only, either from each other or from authenticated material of *E. leptocephalum*. On the other hand they may be distinguished from the typical Colombian form of *E. tequendamense* (= *E. subscandens* Hieron.) in having more slender fewer-flowered heads, straight pedicels, and leaves much more attenuate at the base. To *E. leptocephalum* the following Ecuadorian material may be referred. PICHINCHA: Quito, *Jameson* (Gr.); Nieblí, *Sodiro*, no. 6/26 (Berl., fragm. Gr.). PROVINCE NOT INDICATED: *Seemann* (Gr.).

2. E. ODORATUM L. (see p. 280). *E. floribundum* HBK. Nov. Gen. et Spec. iv. 118, t. 344 (1820); *Jameson*, Syn. Pl. Aeq. ii. 80 (1865). *E. conyzoides*, var. *floribundum* (HBK.) Hieron. in Engl. Bot. Jahrb. xxix. 5 (1900), as *floribunda*.— LOJA: between Loja and the Rio Catamayo, *Humboldt & Bonpland*, no. 3426 (Par., phot. Gr.); in mountains, acc. to Jameson, l. c. CHIMBORAZO: in the Valley of Pallatanga, alt. 1600 m., *Sodiro*, no. 6/27, acc. to Hieronymus, l. c.

3. E. LAEVIGATUM Lam. (see p. 273); Hieron. in Engl. Bot. Jahrb. xxix. 5 (1900).— PICHINCHA: in temperate region, near Nieblí, alt. 1400–2000 m., *Sodiro*, no. 6/25, acc. to Hieronymus, l. c.

4. E. EGGERSII Hieron. Climbing smoothish shrub with round widely spreading branches; leaves opposite, elliptical-ovate, obtusish or shortly acuminate to an obtuse point, rounded at base, glabrous, 3–4.5 cm. long, 2.4–2.8 cm. wide, conspicuously 3-nerved, the nerves prominent beneath, depressed in furrows above; panicles leafy-bracted, the opposite spreading branches capituliferous chiefly toward their ends; heads about 10-flowered, subsessile in ovoid to subglobose glomerules; involucral scales stramineous, about 4-seriate, ovate, ciliate, narrowed to an obtuse hairy appressed tip, mostly with a broadish median nerve closely flanked by two narrow lateral ones; corollas glabrous, the tube about 3 mm. long, scarcely enlarged into a throat about 2 mm. long; achenes glabrous, blackish, 5(–7)-costate, about 3 mm. long; pappus-bristles stiffish, yellowish-white.— Hieron. in Engl. Bot. Jahrb. xxviii. 566 (1901).— MANABÍ: near the Hacienda El Recreo, *Eggers*, no. 15,414 (Berl., phot. and fragm. Gr.).

Sect. II. SUBIMBRICATA (DC.) Hoffm. (see p. 281).

KEY TO SPECIES.

a. Leaves pinnately veined; shrubs or trees *b.*

b. Heads 4–12-flowered *c.*

c. Leaves ovate to broadly oblong, 8–13 cm. wide, pellucid-punctate.......................................14. *E. morifolium.*

c. Leaves narrowly oblong, 1–2 cm. wide, not pellucid-punctate.......................................5. *E. salicinum.*

b. Heads 14–40-flowered *d.*

d. Leaves lance-oblong, cordate at base............6. *E. glutinosum.*

d. Leaves not cordate; a group of very closely related and perhaps wholly artificial species likely to be found confluent when better known *e.*

e. Erect shrubs or small trees *f.*

f. Branches tetragonal; leaves cuneate at base *g.*

g. Heads about 20-flowered; leaves elliptic-lanceolate, almost equally pointed at the ends, white-tomentose beneath, 3 times as long as wide..7. *E. cacalioides.*

g. Heads about 15-flowered; leaves oblong-lanceolate, gradually acuminate to the apex, more abruptly cuneate at base, about 4 times as long as wide, yellowish-tomentose beneath.....8. *E. buddleaefolium.*

f. Branches hexagonal; leaves rounded at base or very shortly acuminate to the point of attachment *h.*

h. Leaves white-tomentose beneath; erect shrub 9. *E. persicifolium.*

h. Leaves delicately and somewhat obscurely pubescent beneath; tree..........................10. *E. arboreum.*

e. Climbing shrub; branches round, sulcate; leaves rounded at the base, canescent-tomentose beneath 11. *E. salviaefolium.*

a. Leaves palmately 3(–7)-nerved from the base or from a point somewhat above the base or if pinnately veined having 2 of the lower lateral veins considerably longer and more conspicuous than the rest *i.*

i. Heads 4–12- or rarely (in *E. lloense*) as many as 16-flowered *j.*

j. Leaves strongly discolorous, the lower surface conspicuously whitened by a minute lanulate pubescence; heads about 11-flowered *k.*

k. Leaf-blade ovate-oblong, obtuse, rounded at the base 12. *E. origanoides.*

k. Leaf-blade deltoid-ovate, acutish, cordate at the base 13. *E. niveum.*

j. Leaves (when mature) never whitened beneath *l.*

l. Heads thrysoid; leaves very large (12–20 cm. long, 8–13 cm. wide)...............................14. *E. morifolium.*

l. Heads corymbed or loosely panicled; leaves considerably smaller *m.*

m. Inflorescence an open panicle *n.*

n. Heads 12–16-flowered; leaves ovate-lanceolate, glabrous beneath...........................15. *E. lloense.*

n. Heads about 5-flowered, disposed singly or by few-headed glomerules in a loose forking cymose panicle; leaves sparingly pubescent to velvety beneath . . . . 16. *E. iresinoides.*
m. Inflorescence compact; heads crowded *o.*
o. Leaves obtusish or barely acute *p.*
p. Heads sessile or nearly so; leaves crenate almost from the base; shrub . . . . 17. *E. chamaedrifolium.*
p. Heads slender-pedicelled; leaves crenate from about the middle or subentire; tree . . . . . 18. *E. prunifolium.*
o. Leaves acuminate or attenuate *q.*
q. Leaves ovate, slender-petioled *r.*
r. Leaves thin, delicately membranaceous; involucral scales ciliate but slightly if at all dorsally pubescent; corollas about 3.5 mm. long . . . . 19. *E. pseudoglomeratum.*
r. Leaves thickish or somewhat firm *s.*
s. Scales dorsally pubescent as well as ciliate; corollas (probably white) 3.5 mm. long 20. *E. pseudoriganoides.*
s. Scales ciliate but essentially glabrous dorsally; corollas (lilac-blue) 5.5–6 mm. long . 21. *E. Stuebelii.*
q. Leaves rhombic-ovate or lanceolate, subsessile or on short thickish petioles . . . . 22. *E. inulaefolium.*
i. Heads 18–70-flowered *t.*
t. Heads densely corymbed *u.*
u. Leaves deltoid-ovate, 2–3 cm. long, coarsely crenate; petioles 2–4 mm. long . . . . 23. *E. rugosum.*
u. Leaves 6–9 cm. long; petioles 5–10 mm. long *v.*
v. Leaves ovate or ovate-lanceolate, more than half as long as broad, punctate but essentially glabrous beneath . . . . 24. *E. obscurifolium.*
v. Leaves ovate-lanceolate, about a third as long as broad, pubescent and glandular-atomiferous beneath . . . . 25. *E. chimborazense.*
t. Heads loosely panicled *w.*
w. Climbing shrub; leaves coriaceous; heads 10–12 mm. high . . . . 26. *E. vitalbae.*
w. Annual herb; leaves thin, membranaceous; heads about 4 mm. high . . . . 27. *E. microstemon.*

5. E. SALICINUM Lam. (see p. 286); HBK. Nov. Gen. et Spec. iv. 131 (1820); Jameson, Syn. Pl. Aeq. ii. 81 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 11 (1900).— PICHINCHA: at the base of Mt. Pichincha, alt. 3050 m., *Jameson,* no. 154 (K.). CHIMBORAZO: at the foot of the Volcano Tungeragua, near the village of Penipe, alt. 2470 m., *Humboldt & Bonpland* (Par., phot. Gr.). PROV. NOT INDICATED: in shade among thickets on high plains, *Sodiro,* no. 6/28, acc. to Hieron. l. c.

Although no material of *E. Jamesonii* Turcz. Bull. Soc. Nat. Mosc. xxiv. pt. 1, 169 (1851) has been seen by the writer, it is impossible from its character and habitat to doubt its identity with *E. salicinum* Lam., with which it appears to agree fully in all important features.

6. E. GLUTINOSUM Lam. Shrub or small tree 2–3 m. high; branches terete, striate-angulate, purple, glandular-pubescent, vernicose and very sticky; leaves opposite, petiolate, lanceolate, gradually narrowed from near the cordate base to the attenuate tip, 7–12 cm. long, 2–3 cm. wide, thickish, glabrous and lucid but deeply bullate and rugulose above, white-velvety beneath; petiole 1–1.8 cm. long; corymbs terminal, scarcely exceeding the leaves, many-headed but not very crowded; pedicels mostly 1–1.5 cm. long, purple, glandular-puberulent, viscid, flexuous; heads 1 cm. high and equally thick, about 30-flowered; involucre campanulate, 5 mm. high; scales about 22, moderately unequal but rather loosely imbricated (transitional between § *Subimbricata* and § *Eximbricata*), the outer ovate, the intermediate lanceolate, acute or acuminate, dorsally convex, glandular-puberulent, the innermost linear; corollas purple, smooth, 5.5 mm. long, very slightly and gradually enlarged from near the base to the summit but without clearly marked throat; achenes glabrous; pappus-bristles about 37, yellowish-white, slightly stiffish, finely hispidulous.— Encyc. ii. 408 (1786); HBK. Nov. Gen. et Spec. iv. 131 (1820); Benth. Pl. Hartw. 198 (1845); Jameson, Syn. Pl. Aeq. ii. 84 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 10 (1900), xxviii. 571 (1901).— PICHINCHA: 1833, *F. Hall* (sk. and fragm. Gr.); Andes of Quito, *Jameson* (Gr.). PICHINCHA OR LEON: between Mulaló and El Tambillo, alt. 2745 m., *Humboldt & Bonpland.* CHIMBORAZO: in the upper region of thickets near Pangor and Huangopod, near Cajabamba, alt. 2900–3400 m., *Lehmann,* no. 5191 (N. Y.); in scattered thickets on the western slopes of Chimborazo and Mt. Tiupullo, alt. 3000–3300 m., *Lehmann,* no. 7960, acc. to Hieron. l. c. PROV. NOT INDICATED: in the Achupoyas Mountains, *Hartweg,* no. 1094 (sk. and fragm. Gr.). VERNACULAR NAMES: *matico, chusalonga.*

7. E. CACALIOIDES HBK. A shrub with tetragonal dark-purple viscid or vernicose branches; leaves opposite, petiolate, oblong-lanceolate, acuminate at apex, almost equally pointed at base, 7–8 cm. long, 2–2.6 cm. wide, subcoriaceous, glabrous, finely reticulated and dark-green above, canescent-tomentose beneath; petiole 1.5 cm. long, smoothish, channelled above; corymbs terminal, dense, not exceeding the leaves; branchlets and pedicels pubescent; heads sessile and pedicelled, about 8 mm. high, about 20-flowered; corollas tubular, glabrous, blue (Townsend); achenes dark, 3 mm. long, hispidulous-roughened on the ribs.— Nov. Gen. et Spec. iv. 130 (1820); Jameson, Syn. Pl. Aeq. ii. 86 (1865).— PICHINCHA? "in Regno Quitensi?" *Humboldt & Bonpland* (Par., phot. Gr.). CHIMBORAZO:

Cordillera de Riobamba, acc. to Jameson, l. c. LOJA: between Utuana and Colaisaca, alt. 2540–2640 m., *C. H. T. Townsend*, no. 995 (U. S.). Pressed leaves have the odor of licorice (Townsend).

8. E. BUDDLEAEFOLIUM Benth. Shrub; branches purplish-brown, smooth, shining, vernicose; internodes about 5 cm. long, somewhat compressed-tetragonal, with concave slightly costulate surfaces; leaves opposite, petiolate, lance-oblong, serrulate-denticulate from the cuneate base to the gradually acuminate apex (teeth very numerous, 0.4–0.8 mm. high, 1.5–2.3 mm. broad), green, glabrous, and lucid above, strongly 1-costate and pinnately many-veined (veins 30–40 on each side, leaving the midrib at an angle of 65°–87°), reticulated beneath, the surface gray-tomentose, the veins nearly smooth, slightly coriaceous, 1–1.5 dm. long, 2–3.2 cm. wide; petiole 1–1.8 cm. long; corymb terminal, trichotomous, surpassed by the leaves, glabrous but viscid; heads 14–15-flowered, sessile or nearly so, 11 mm. long, 5 mm. in diameter; involucre subcylindric-campanulate, about 5-seriate; scales about 25, stramineous, long-ciliate, otherwise subglabrous, viscid, the outer ovate to ovate-lanceolate, often purple-tipped, the innermost linear, readily deciduous; corollas presumably purple, 4.8 mm. long, glabrous, the tube gradually enlarged from near the base to the limb but without distinctly marked throat; achenes about 3 mm. long, sparingly hispid on the angles; pappus-bristles very numerous (about 70) and finely capillary, yellowish-white.— Pl. Hartw. 135 (1844); Jameson, Syn. Pl. Aeq. ii. 81 (1865). Incorrectly reduced to *E. arboreum* by Hieron. in Engl. Bot. Jahrb. xxix. 10 (1900). — LOJA: in mountains, *Hartweg*, no. 757 (K., sk. Gr.). PROV. NOT INDICATED: Quitensian Andes, 1855, *Couthouy* (Gr.). [Peru, Prov. of Chachapoyas, *Mathews*.] Compared by Bentham to *E. salicinum* Lam., but not closely related. *E. salicinum* has tomentose branches and subsessile nearly entire leaves of different texture and venation, the lateral veins being only 6–8 on each side and leaving the midrib at an angle of only about 45°.

9. E. PERSICIFOLIUM HBK. Erect shrub; branches hexagonal, subglabrous, arcuate or flexuous; internodes 4–8 cm. long; leaves opposite, petiolate, oblong-lanceolate, attenuate-acuminate at the apex, at base rounded in general contour but slightly cuneate at the point of insertion on the petiole, denticulate or crenulate, subcoriaceous, glabrous and rugulose above, white-tomentose beneath, about 9 cm. long and 2.5–3 cm. wide; petiole about 1.5 cm. long; corymb terminal, exceeded by the leaves, rounded, trichotomous; heads about 25-flowered, mostly pedicelled though crowded in the partial inflores-

cences; involucre about 4-seriate, narrowly campanulate; scales about 30, ovate-lanceolate to linear, acute, viscid; corollas about 5.5 mm. long, glabrous; achenes 5 mm. long, sparingly glandular between the scabrous ribs (f. Hieron.).— Nov. Gen. et Spec. iv. 130 (1820); Hieron. in Engl. Bot. xxix. 10 (1900). *E. persicaefolium* [HBK.] DC. Prod. v. 162 (1836); Jameson, Syn. Pl. Aeq. ii. 86 (1865).— LEON: base of Cotopaxi, near Mulaló, alt. 2928 m., *Humboldt & Bonpland* (Par., phot. Gr.). TUNGURAGUA: near Mocha, *Sodiro*, no. 6/23a, acc. to Hieron. l. c.

10. E. ARBOREUM HBK. A small tree in technical characters exceedingly close to the preceding; branches also hexagonal and smooth, those of the inflorescence sordid-pubescent; leaves much as in the preceding but in the type-material really rounded at base, densely sordid-pubescent beneath; corymbs rounded, about equalling or slightly exceeding the leaves; heads about 25-flowered; involucre somewhat turbinate-campanulate; scales fuscous-stramineous, ciliate and dorsally somewhat puberulent or pulverulent, inclining to viscidity, acute, the outer ovate-lanceolate, the inner linear.— Nov. Gen. et Spec. iv. 131 (1820); Jameson, Syn. Pl. Aeq. ii. 87 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 10 (1900), excl. syn. *E. buddleaefolium*.— CHIMBORAZO: between Pomallacta and Alausí, alt. 2562 m., *Humboldt & Bonpland*, no. 3240 (Par., phot., sk., and fragm. Gr.); on slopes of Chimborazo, *Sodiro*, no. 6/16, acc. to Hieron. l. c.— TUNGURAGUA: near Ambato, *Sodiro*, no. 6/23b, acc. to Hieron. l. c. The Peruvian *E. discolor* DC. Prod. v. 161 (1836), reduced by Hieronymus, l. c., to this species, is shown by the original in the Prodromus Herbarium at Geneva to have leaves cuneate at base, much less toothed (indeed only obsoletely crenulate), and much more densely and copiously white-tomentose beneath.

11. E. SALVIAEFOLIUM HBK. A climbing shrub with terete shallowly furrowed sticky branches; leaves opposite, deflexed, oblong-lanceolate, gradually acuminate, rounded at base, deeply crenulate-denticulate (some of the teeth triangular and rather sharp, others ovate-oblong and rounded at the tip), coriaceous, glabrous and green but bullate-rugose above, white-tomentose beneath, 7–8 cm. long, 1–2.5 cm. wide; petiole about 1 cm. long; corymb terminal, rounded; heads glomerulate; involucre and florets as in the two preceding species.— Nov. Gen. et Spec. iv. 131 (1820); Jameson, Syn. Pl. Aeq. ii. 88 (1865).— CHIMBORAZO: in cool places on slopes of Chimborazo, alt. 3294 m., *Humboldt & Bonpland*, no. 3144 (Par., phot. Gr.).

12. E. ORIGANOIDES HBK. (see p. 284); Benth. Pl. Hartw. 198

(1845); Jameson, Syn. Pl. Aeq. 85 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 9 (1900).— PICHINCHA: Andes of Quito, 1855, *Couthouy* (Gr.); 1859, *Jameson* (Gr., N. Y.); near Guapulo, *Hartweg*, acc. to Benth. l. c.— PROV. NOT INDICATED: in subandean thickets, alt. 2000–3400 m., *Sodiro*, no. 6/24, acc. to Hieron. l. c. [Colombia.]

13. E. NIVEUM HBK. (see p. 285); Benth. Pl. Hartw. 198 (1845); Jameson, Syn. Pl. Aeq. 83 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 7 (1900).— PICHINCHA: alt. 3050 m., *Couthouy* (Gr.); Rumibamba, *Hartweg*, no. 1096; Andes of Quito, *Jameson* (Gr., N. Y.). PROV. NOT INDICATED: in subandean thickets, alt. 2000–3400 m., *Sodiro*, no. 6/24, acc. to Hieron. l. c.

14. E. MORIFOLIUM Mill. (see p. 293). *E. populifolium* HBK. Nov. Gen. et Spec. iv. 111 (1820); Hieron. in Engl. Bot. Jahrb. xxix. 7 (1900).— PICHINCHA: near San Nicolas, alt. 800–900 m., *Sodiro*, no. 6/29, acc. to Hieron. l. c.

15. E. LLOENSE Hieron. Herbaceous perennial, perhaps slightly woody toward the base; stems slender, flexuous, terete, dark-colored, puberulent; leaves opposite, petiolate, rhombic-ovate or -lanceolate, crenate-serrate except at the acuminate or attenuate apex and more abruptly cuneate entire base, 3-nerved, membranaceous, sparingly pubescent above when young, at maturity essentially glabrous, dark-green above, dull and somewhat paler beneath, 3–5 cm. long, 1.4–2 cm. wide; petiole 1–2 cm. long; panicle terminal, opposite-branched, subcorymbous, loose; pedicels filiform, 4–9 mm. long, often curved, finely pubescent and somewhat glandular; heads about 12–16-flowered, often nodding; involucre campanulate; scales about 12, thin, subscarious, very unequal, the outer short, ovate-oblong, acute, dorsally puberulent, the inner oblong-linear, mostly with 3 fine green nerves and 2 pale ribs, almost smooth; corollas white or nearly so, 3–3.5 mm. long, glabrous; proper tube about 1 mm. long, gradually passing into a scarcely enlarged cylindrical throat; achenes about 1.6 mm. long, grayish-brown, glabrous, callose at base; pappus-bristles delicately capillary, white.— Hieron. in Engl. Bot. Jahrb. xxix. 11 (1900).— PICHINCHA: Andes of Quito, 1855, *Couthouy* (Gr.); Valley of Lloa, alt. 2745 m., *Jameson*, no. 373 (K.); in bushy places, valley of Lloa, at the base of Mt. Pichincha, *Sodiro*, no. 9/2 (Berl., fragm. Gr.).

16. E. IRESINOIDES HBK. (see p. 285). *E. iresinoides*, var. *villosum* Steetz, in Seem. Bot. Herald, 145 (1854); Hieron. in Engl. Bot. Jahrb. xxix. 12 (1900).— GUAYAS: at borders of woods, near Guayaquil, *Sodiro*, no. 6/21, acc. to Hieron. l. c.

17. E. CHAMAEDRIFOLIUM HBK. Upright shrub; stems virgate or trichotomously forked; the branches curved-ascending, terete, velvety-pubescent; leaves opposite, subsessile or shortly petioled, ovate or oval, obtuse or rounded at the tip, rounded at base, crenulate, thickish, subcoriaceous, 3-nerved, sparingly pubescent above, softly sordid- or dark-pubescent beneath, about 2 cm. long and 1.5 cm. wide; petiole 2–3 mm. long; corymbs terminal, compact, 3–6 cm. in diameter; heads 10–12-flowered; involucre campanulate-cylindrical; scales closely appressed, oval to oblong-linear, green, somewhat striate, ciliate, often purplish at the obtuse tip; corollas violet, glabrous; achenes almost black, roughened on the angles, 2 mm. long.—Nov. Gen. et Spec. iv. 113 (1820); Jameson, Syn. Pl. Aeq. ii. 81 (1865).—LOJA: in the mountains, acc. to Jameson, l. c. [Peru.]

18. E. PRUNIFOLIUM HBK. Small tree, about 4 m. high; branches terete, shallowly ribbed or furrowed, pubescent; leaves opposite, ovate-oblong, scarcely acute at the tip, rounded at base, quite entire or shallowly crenate above the middle, coriaceous, 3-ribbed from somewhat above the base, 3–3.6 cm. long, half as wide, dark-green, smooth, and glabrous above, paler, pubescent, and prominently reticulated beneath; petiole 6–8 mm. long; corymbs chiefly terminal (occasionally becoming lateral), rounded, about 6 cm. in diameter, dense; pedicels 4–6 mm. long, pubescent; heads about 12-flowered, 1 cm. high; involucre campanulate-subcylindrical, loosely imbricated, 5–6 mm. high; scales about 12, oblong to linear, glabrous, purplish at tip, the outer acute, glutinous; corollas white, with differentiated tube and throat, smooth; achenes about 3 mm. long, black; pappus-bristles dusky, roughened.—Nov. Gen. et Spec. iv. 132, t. 349 (1820); Jameson, Syn. Pl. Aeq. ii. 83 (1865).—PICHINCHA: in the gorge of Tarqui near Quito, alt. 2470 m., *Humboldt & Bonpland*, no. 3287 (Par., phot. and sk. Gr.). Referred here, as by DeCandolle, to § *Subimbricata* but in involucral character transitional between this group and § *Eximbricata*.

19. E. PSEUDOGLOMERATUM Hieron. (see p. 291).—PICHINCHA: Andes of Quito, 1855, *Couthouy* (Gr.); environs of Quito, *Jameson*, no. 893 (K.). PROV. NOT INDICATED: in moist bushy places, alt. 2000 m., *Sodiro*, nos. 6/2 (Berl., fragm. Gr.), 6/4 (Berl., phot. Gr.), and 6/10 (Berl.). [Colombia.]

20. E. PSEUDORIGANOIDES Hieron. Shrub; branches spreading, terete, finely striate, at first pubescent, later glabrate; leaves opposite, ovate, long-acuminate, rounded at base, crenate to subentire, thickish, subcoriaceous, above glabrous, lucid, bullate and rugose, beneath

dull and covered with a soft olivaceous pubescence, 3(–5)-ribbed, 2.5–4 cm. long, half as wide; petiole 4–12 mm. long; inflorescence a much branched compound terminal hemispherical corymb or a leafy-bracted dense pyramidal panicle; heads 10–12-flowered, 7 mm. high, shortly slender-pedicelled or some sessile in the forks of the cymose branching; involucre campanulate, about 3-seriate; scales pale, scarious-stramineous, thin, ciliate, dorsally pubescent or at least pulverulent-puberulent, the outer broadly ovate, rounded at the tip, the inner oblong, obtuse; corollas 3 mm. long, apparently white, the proper tube about equalling the scarcely differentiated but slightly expanded throat, glabrous; achenes 1.8 mm. long, glabrous.— Hieron. in Engl. Bot. Jahrb. xxix. 10 (1900).— PICHINCHA: Andes of Quito, *Jameson*, no. 68 (K.). AZUAY: Surucucho, near Cuenca, *Jameson* (K.). PROV. NOT INDICATED: sterile places in the interandean region, *Sodiro*, no. 6/24b (Berl., phot. and fragm. Gr.); without locality, *Jameson* (U. S.).

21. E. STUEBELII Hieron. (see p. 288).— CHIMBORAZO: Campamento Utiñag, valley of the Rio Chambo, alt. 3045 m., *Stübel*, no. 272 (Berl., phot. and fragm. Gr.). [Colombia.]

22. E. INULAEFOLIUM HBK., f. SUAVEOLENS (HBK.) Hieron. (see p. 291).— CHIMBORAZO: Pallatanga Valley, alt. 2000 m., *Sodiro*, no. 6/12, acc. to Hieron. l. c.

23. E. RUGOSUM HBK. Shrub; branches trichotomous, round, softly pubescent, curved-ascending; leaves opposite, short-petioled, triangular-ovate, obtuse at apex, subtruncate, rounded, obtuse, or barely acute at base, crenate, scabrid and bullate-rugose above, canescently hispid-tomentose beneath, 3–3.6 cm. long, 2.4–2.8 cm. wide; petiole 4–5 mm. long; corymbs dense, terminal, 4.5–7.5 cm. in diameter; heads 18–20-flowered, 1.4 cm. high; involucre narrowly campanulate; scales about 30, the inner narrowly oblong, pale-green, substramineous, ciliate, obtuse, the intermediate and outer much broader, firmer in texture, dark-violet toward the broadly rounded tip, narrowed below, mostly 5-ribbed, the ribs united at base; corollas pale-purple, smooth, except for some granulation on the outside of the limb, 5-nerved, about 5 mm. long; achenes hispid near the summit; pappus-bristles yellowish-white, hispid-roughened, unequal. — Nov. Gen. et Spec. iv. 114 (1820); Jameson, Syn. Pl. Aeq. ii. 87 (1865).— CHIMBORAZO: on dry open hills between Alausí and Cerro de Sitzan, alt. 2288 m., *Humboldt & Bonpland*, no. 3227 (Par., phot., sk., and fragm. Gr.).

24. E. OBSCURIFOLIUM Hieron. Erect or somewhat decumbent

herb, reaching 2 m. in height; stem terete, sordid-puberulent; hairs short, spreading, flexuous, attenuate; internodes 4–6(–8) cm. long; leaves opposite, petiolate, narrowly ovate, gradually narrowed to an acutish or acuminate apex, rounded at the base, bluntly serrate-dentate, membranaceous, 3-nerved from the base, puberulent on the nerves, fuscous-brown or dark-olivaceous in drying, dull, 4–6 cm. long, about half as wide; petiole 8–11 mm. long; corymbs trichotomous, leafy-bracted at base; heads 30–70-flowered (Hieronymus), 9 mm. high, pedicellate; involucral scales about 25, somewhat graduated, about 3-seriate, lance-linear, mostly 2-ribbed, the ribs united at base into a conspicuous elongated callosity; corollas reddish-lilac (Lehmann), 4.5 mm. long, slender, slightly and gradually enlarged upward, hispidulous near the limb; achenes smooth, shining, dark-brown, 2 mm. long.— Hieron. in Engl. Bot. Jahrb. xxix. 9 (1900).— AZUAY: in dense thickets, near Chagál and Yerbas-buenas, on the slopes of the western Andes, near Cuenca, alt. 2000–2700 m., *Lehmann*, nos. 4884 (Berl., fragm. Gr.) and 7984 (Berl., phot. Gr.). CHIMBORAZO: in the subandean region, *Sodiro*, no. 6/7b, acc. to Hieron. l. c. [Colombia, acc. to Heering.]

25. E. CHIMBORAZENSE Hieron. Presumed to be suffruticose and climbing; the round stems glandular-pubescent; internodes 4–5 cm. long; leaves opposite, slender-petioled, ovate-lanceolate, caudate-attenuate, rounded at base, serrulate, firm-membranaceous or subchartaceous, above puberulent, in age rugose and bullate, below sordid- or olivaceous-pubescent and copiously covered with sessile glands, subtriplinerved then pinnate-veined and prominently reticulated, 7–9 cm. long, 2.4–3 cm. wide; petiole 1.3–2 cm. long; corymb dense, terminal, about 6 cm. in diameter; heads subsessile or on short thick and densely pubescent pedicels, 25–40-flowered, about 9 mm. long; involucre campanulate; scales graduated, about 4-seriate, narrowed to an acute tip, the outer ovate, dorsally crisped-puberulent, the intermediate and inner gradually longer, narrower, and smoother, mostly 3-nerved; corollas (in dried material showing 5 dark nerves) 5 mm. long, glabrous, slenderly tubular, slightly and gradually enlarged upward; achenes 2.5 mm. long, glabrous; pappus-bristles yellowish-white, minutely scabrid.— Hieron. in Engl. Bot. Jahrb. xxix. 7 (1900).— CHIMBORAZO: on slopes of Mt. Chimborazo, *Sodiro*, no. 6/15 (Berl., phot. and fragm. Gr.).

26. E. VITALBAE DC. (see p. 299); Hieron. in Engl. Bot. Jahrb. xxix. 11 (1900). *E. ecuadorae* Klatt, Ann. k. k. Naturh. Hofmus. Wien, ix. 356 (1894).— GUAYAS: in dense woods near Naranjal,

Lehmann, no. 5686 (N. Y.); near Balao, *Eggers*, no. 14,086 (N. Y.). PICHINCHA: in subtropical region, alt. 2000 m., near Nieblí, *Sodiro*, no. 6/22, acc. to Hieron. l. c. PROV. NOT INDICATED: without locality, *Jameson* (sk. and fragm. Gr.).

27. E. MICROSTEMON Cass (see p. 295). *E. guadalupense* DC. Prod. v. 170 (1836) and probably of Hieron. in Engl. Bot. Jahrb. xxix. 12 (1900), excl. syn. "*E. Sinclairii*" [*Sinclairi*], although described as "herba prostrata."— CHIMBORAZO: San José, on western slopes of Mt. Chimborazo, *André*, no. 6 of his second series (Gr.); ? in woods of subtropical valleys, Pallatanga, *Sodiro*, no. 6/29, acc. to Hieron. l. c. (as *E. guadalupense*).

Sect. III. EXIMBRICATA (DC.) Hoffm. (see p. 303).

KEY TO SPECIES.

a. Leaves coriaceous *b.*
b. Leaves (the mature cauline) cordate *c.*
c. Delicate flexuous herb; leaves 3-nerved from the base, 2–2.5 cm. long . . . . 41. *E. cuencanum.*
c. Viscid shrub; leaves feather-veined, 7–12 cm. long . . 6. *E. glutinosum.*
b. Leaves not cordate *d.*
d. Heads 3–12-flowered *e.*
e. Leaves pubescent beneath . . . . 18. *E. prunifolium.*
e. Leaves glabrous on both surfaces *f.*
f. Heads 3–7-flowered; very closely related species likely to prove more or less confluent when known from more copious material *g.*
g. Leaves more or less nerved, either 3-nerved from the base or with 2 pairs of nerves one nearly basal the other starting somewhat above the base *h.*
h. Leaves 5–13 cm. long, 2.4–4.5 cm. wide . . . 28. *E. pseudochilca.*
h. Leaves 3–4 cm. long, 1.8–2.6 cm. wide *i.*
i. Leaves obsoletely serrulate above the middle; teeth 4–7 on each side . . . . 29. *E. umbrosum.*
i. Leaves serrate-dentate at least above the middle; teeth 9–19 on each side . . . . 30. *E. cotacachense.*
g. Leaves truly feather-veined, the lower veins not enlarged or more conspicuous than the others *j.*
j. Leaves 3–9 cm. long; reticulation relatively coarse (ultimate areolae about 1 mm. in diameter); petiole 8–10 mm. long . . . . 31. *E. exserto-venosum.*
j. Leaves 9–12 cm. long; reticulation very fine (ultimate areolae about 0.5 mm. in diameter); petiole about 2 cm. long . . . . 32. *E. dendroides.*
f. Heads about 12-flowered . . . . 33. *E. fastigiatum.*
f. Heads 20–∞-flowered *k.*
k. Leaves elliptical, rounded at base; petiole about 5 mm. long . . . . 34. *E. elegans.*

k. Leaves ovate, acute at base; petiole 1.4–1.8 cm. long . . . . 35. *E. viscosum.*

a. Leaves membranaceous *l.*

l. Leaves sessile; pedicels copiously glandular . . . . . . 36. *E. glanduliferum.*

l. Leaves petioled (shortly so in *E. gracile*, v. *epilobioides*, which, however, does not have glandular pedicels) *m.*

m. Heads subracemosely disposed in a pyramidal panicle 37. *E. solidaginoides.*

m. Heads corymbose or in flattish cymes *n.*

n. Leaves ovate-suborbicular *o.*

o. Spreading-villous; teeth of leaves about 14 on each side; heads 40–45-flowered . . . . 38. *E. pichinchense.*

o. Puberulent; teeth of leaves 6–9 on each side; heads 25–30-flowered . . . . 39. *E. Sodiroi.*

n. Leaves deltoid-ovate to ovate-lanceolate *p.*

p. Petiole short, one-tenth to one-fifth as long as the blade; inflorescence sparingly pubescent, the hairs slender, attenuate, articulated, curved-ascending or subappressed . . . . 40. *E. gracile*, v. *epilobioides.*

p. Petiole relatively longer, one-fourth to two-thirds as long as the blade; inflorescences puberulent with stipitate glands *q.*

q. Heads 16–19-flowered; stems glabrous to the inflorescence . . . . 41. *E. cuencanum.*

q. Heads 25–40-flowered; stem puberulent much below the inflorescence *r.*

r. Heads about 7 mm. high . . . . 42. *E. glechonophyllum.*

r. Heads slightly larger, about 9 mm. high; leaves lanceolate to deltoid-ovate . . . . . . 43. *E. azangaroense.*

28. E. PSEUDOCHILCA Benth. Shrub, smooth but viscid, 9–15 dm. high; branches round, very leafy; internodes mostly 1.5–2 cm. long; leaves opposite, ovate-oblong, petiolate, 6–7 cm. long, 3–4 cm. wide, scarcely acute, rather finely serrate except at the entire and rounded base, firm in texture, glabrous and reticulated on both surfaces, lucid above, dull beneath; petiole about 1 cm. long; corymb dense, rounded, 8 cm. in diameter, many-headed, slightly puberulent, or beset with sessile glands; heads 5–6-flowered, about 7 mm. long; involucral scales few, subequal, 3–4 mm. long, oblong, obtuse, dark-purple toward the tip, beset with sessile glands; corollas 5.5 mm. long; proper tube 1.5 mm. long, beset with a few sessile glands; throat about 4 mm. long, glabrous; achenes (immature) 1.5 mm. long, hispidulous toward the summit especially on the angles; pappus-bristles about 30, unequal, yellowish-white, slightly stiffish, somewhat roughened, the longest about 4 mm. in length.— Pl. Hartw. 198 (1845); Jameson, Syn. Pl. Aeq. ii. 85 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 7 (1900), excl. syn. *E. prunifolium* Klatt, which is a much smaller-leaved plant apparently not distinguishable from *E. cotacachense* Hieron.— PICHINCHA: Rumibamba (thus on original label but incor-

rectly cited as Riobamba by Benth. l. c.), village of Guapulo, Haciendo de Pinantura, *Hartweg*, no. 1095 (K., N. Y., phot. G.); Andes of Quito, alt. 3050 m., *Jameson* (Gr.).

29. E. UMBROSUM Benth. Sticky shrub with flexuous slightly hexagonal branches; leaves opposite, short-petioled, elliptical, 2.5–4 cm. long, 15–20 mm. wide, acutish, mucronate, rather abruptly cuneate at base, obsoletely serrulate above the middle, the teeth very few (4–7 on each side), 3-nerved from the base, rather firm, glabrous on both surfaces; petiole 2–5 mm. long; inflorescence considerably exceeding the leaves, pedunculate, fastigiately branched, dense, many-headed, strongly convex, about 8 cm. in diameter; heads 6–7-flowered; involucre narrowly campanulate, its scales 8–10, lance-oblong, acutish, viscid, about 2-seriate, subequal.— Pl. Hartw. 198 (1845); Jameson, Syn. Pl. Aeq. ii. 84 (1865).—PICHINCHA: in shade, Rumibamba, near Quito, *Hartweg* (unnumbered unicate, K., phot. Gr.).

30. E. COTACACHENSE Hieron. Shrub, 2–3 m. high, smooth except for a sparing and somewhat obscure puberulence on the young often vernicose and sticky parts; branches erect or curved-ascending, irregularly quadrangular, leafy; internodes 1–4 cm. long; foliage yellowish-green when fresh, often fuscous after drying; leaves lanceolate-oblong to elliptical, acute or obtusish, serrate or crenate except at the entire more or less cuneate base, 3–4 cm. long, 2–2.6 cm. wide, firm in texture, 3-nerved from above the base, a pair of smaller intramarginal nerves between the main nerves and the actual base, both surfaces finely reticulated, the veinlets prominulent, teeth 9–19 on each side; petiole about 5 mm. long, canaliculate above; corymbs dense, many-headed, 4–6 cm. in diameter, strongly convex, fastigiate, about equalling or sometimes exceeding the leaves; heads 3–5-flowered, about 7 mm. high; involucre narrowly campanulate, the scales 5–7, subequal, lance-oblong, obtusish to rounded at the apex, 3(–5) mm. long, viscid, usually 2-ribbed; corolla white, 5 mm. long; the proper tube 1.5 mm. long, beset with sessile glands, the throat glabrous, 3.5 mm. long; achenes (immature) 1.5 mm. long, granulated.—Hieron. in Engl. Bot. Jahrb. xxi. 331 (1895). *E. prunifolium* Klatt in Engl. Bot. Jahrb. viii. 35 (1887), not HBK.— IMBABURA: Cerro Cotacachi, *Stübel*, no. 59 (Berl., phot. and fragm. Gr.). CARCHI: Páramo de Tuza [Tusa], alt. 3400 m., *Lehmann*, no. 587 (Gr.); in the Andes of Ecuador without precise locality, *Spruce*, no. 5805 (Gr.). Locally called *chilca blanca* (André).

31. E. EXSERTO-VENOSUM Klatt. Glabrous shrub 9–12 dm. high,

slightly viscid-vernicose on the younger parts and inflorescence; branches ascending or erect, at first somewhat quadrangular, leafy; leaves opposite, petiolate, elliptical, obtuse, rounded at the base, crenulate, coriaceous, green and lucid above, slightly paler and somewhat lucid beneath, 2.5–5(–8) cm. long, about half as wide, pinnately veined from base to apex, the veins diverging at a wide angle from the midrib, veinlets reticulated and prominulent on both surfaces; corymb strongly convex, 5–7 cm. in diameter, many-headed, fastigiately branched, dense; heads 6–7-flowered, about 7–8 mm. high; involucre narrowly campanulate; scales 8–10, oblong, obtuse, thickish, obscurely ribbed, essentially glabrous but viscid; corollas about 5 mm. long; proper tube slender, 1–1.5 mm. long, granulated; throat subcylindric, 3.5–4 mm. long, glabrous; achenes (immature) viscidulous; pappus-bristles yellowish-white, stiffish, unequal, the longest about 4 mm. in length.— Abh. Naturw. Ges. Halle, xv. 324 (1882), in advance reprint p. 4 (1881). *E. exerto-venosum* [Klatt] Hook. f. & Jacks. Ind. Kew. i. 917 (1893), by misprint. *E. pseudofastigiatum*, var. *crenata* Hieron. in Engl. Bot. Jahrb. xxxvi. 468 (1905).— [Peru: without locality or number, *Mathews* (fragm. Gr.); Cutero, *von Jelski*, no. 789 (Berl., fragm. Gr.).] This form with elliptical crenately toothed leaves, typical of Klatt's species and of Hieronymus's var. *crenata*, does not thus far appear to have been found in Ecuador. Hieronymus is probably right in classing it and two or three other leaf-forms as varieties of the same species, but seems to have overlooked the prior description of the Mathews plant by Klatt, which necessarily becomes the type of the species, to which the Ecuadorian plant may be appended as a variety, thus:

Var. **pseudofastigiatum** (Hieron.), comb. nov. Leaves ovate-lanceolate, acute or acutish at the apex, rather sharply serrate-dentate from somewhat below the middle, entire and decidedly cuneate at the base; leaf-texture and venation, as well as inflorescence and floral characters, as in the typical variety.— *E. fastigiatum* ? Benth. Pl. Hartw. 135 (1844), not HBK. *E. loxense* Hieron. in Engl. Bot. Jahrb. xxi. 331 (1895), not Klatt. *E. pseudofastigiatum* Hieron. l. c. xxxvi. 467 (1905).— LOJA: in mountains, *Hartweg*, no. 758 (K., Berol., phot. and fragm. Gr.); ECUADOR: without number or more precise locality, *Seemann* (Gr.).

32. E. DENDROIDES (HBK.) Spreng. Tree with glabrous at first somewhat angled soon subterete dark-purple branches; leaves opposite, petiolate, ovate-oblong, narrowed or somewhat acuminate to a mostly obtusish and slightly cuspidate tip, crenate or cuspidate-

serrulate except at the entire cuneate base, 10–12 cm. long, 4–5 cm. wide, pinnate-veined, finely and prominulently reticulate-veined on both surfaces (ultimate areolae about 0.5 mm. in diameter), glabrous and somewhat lucid; midrib sulcate on the upper surface toward the base; petiole 2 cm. long; corymbs compound, as much as 2 dm. in diameter, moderately convex, obscurely puberulent; heads very numerous, shortly pedicelled, usually by 2's or 3's, 5-flowered, 7 mm. long, 4 mm. in diameter; involucre campanulate, 4–5 mm. long; scales about 7, lance-oblong, obtuse, unequal, dorsally granular and viscid, the inner ciliolate at the broadish summit; corollas violet, granulate on the short proper tube, the throat scarcely enlarged, nearly or quite smooth; achenes 2 mm. long, roughened on the angles; pappus-bristles about 21, unequal, hispidulous.— Syst. iii. 415 (1826); Hieron. in Engl. Bot. Jahrb. xxii. 776 (1897), not Bak. *Mikania arborea* HBK. Nov. Gen. et Spec. iv. 139 (1820), not *E. arboreum* HBK. l. c. 131.— LOJA: near Loja, alt. 2013 m., *Humboldt & Bonpland*, no. 3367 (Par., phot. Gr.). [Peru.]

33. E. FASTIGIATUM HBK. (see p. 307).— LOJA: in mountains, acc. to Jameson, Syn. Pl. Aeq. ii. 86 (1865). [Colombia.]

34. E. ELEGANS HBK. Shrub with round virgate pilose-tomentose leafy branches; leaves opposite, subsessile or very shortly petioled, elliptic-ovate, obtuse, crenate-serrulate except at the rounded entire base, feather-veined and reticulated, coriaceous, slightly scabrous on both surfaces, somewhat pubescent on the midnerve and veins beneath, about 3 cm. long, half as wide; corymbs terminal, small, 3–5 cm. in diameter, congested, subsessile, scarcely exceeding the surrounding leaves; heads subsessile; involucre campanulate, the scales 10–15, lanceolate, obtuse; corollas inferred to be white; pappus-bristles whitish, equalling the corolla, hispidulous.— Nov. Gen. et Spec. iv. 133 (1820); Jameson, Syn. Pl. Aeq. ii. 89 (1865).— AZUAY?: in ravine of Tarqui ? *Humboldt & Bonpland* (Par., phot. Gr.). Even in the original description of this species its type-locality is stated with doubt. The plant does not appear to have been rediscovered.

35. E. VISCOSUM HBK. Glabrous viscid shrub; branches hexagonal, leafy; internodes 3–5 cm. long leaves opposite, petiolate, ovate-oblong, narrowed to a scarcely acute apex, crenate-serrate except at the obtusish entire base, conduplicate, coriaceous, 8 cm. long, 3–3.5 cm. wide, smooth and sticky, reticulate-veiny, dark-green and shining above, pale and dull beneath; petiole 1 cm. long; corymb composite, open, irregularly and somewhat fastigiately branched; bracts linear, entire; heads pedicelled, about 40-flowered, 8 mm. high;

involucre campanulate; scales about 17, lanceolate, acute, subequal, dusky-purple, loosely imbricated, a few of the outermost shorter; corollas inferred to be violet, smooth, enlarged in the throat; achenes hispid on the angles; pappus-bristles dusky, hispid.— Nov. Gen. et Spec. iv. 129 (1820); Jameson, l. c. 88.— Inferred (by Kunth) to have been collected in ECUADOR ("crescit in Regno Quitensi?"), *Humboldt & Bonpland* (Par., phot. Gr.).

This species, known to the writer only from the type-material at Paris, is suspiciously close to the Colombian plant subsequently described by Bentham, Pl. Hartw. 200 (1845), as *E. latipes*, which, however, has smaller leaves (3–7 cm. long) and broad petioles only 3–5 mm. in length. It is probable that the latter species will have to be reduced, and it seems not improbable that the original material of *E. viscosum* came not from Ecuador but from the mountains around Bogotá, the source of many of Humboldt & Bonpland's specimens.

36. E. GLANDULIFERUM Hieron. Branching undershrub 1–1.5 m. high; stems terete, often purplish-brown, densely clothed with widely spreading very unequal articulated and for the most part gland-tipped hairs; leaves opposite, sessile, ovate, acuminate, rounded at the slightly clasping base, serrate, 5–6 cm. long, about half as wide, membranaceous, green and slightly glandular-puberulent above, paler and especially on the nerves copiously pubescent beneath; 3-nerved from the base; corymbs terminal, trichotomous, many-headed, rather loose; pedicels filiform, densely glandular-pubescent, 8–18 mm. long; heads about 40-flowered, 8–9 mm. high; involucre campanulate, the scales about 14, subequal, linear, acute, mostly 2-costulate; corollas white, glabrous, 4 mm. long; proper tube slender, 1.5 mm. long; throat cylindrical, 2.5 mm. long; achenes 2.5 mm. long, brownish-black, upwardly hispidulous on the angles, slightly contracted just below a pale pappus-bearing cuplike annulus or disk at the summit.— Hieron. in Engl. Bot. Jahrb. xxix. 13 (1900).— CHIMBORAZO: at the edge of woods on Mt. Chimborazo, *Sodiro*, no. 6/7a (Berl., fragm. Gr.).

37. E. SOLIDAGINOIDES HBK. (see p. 310); Jameson, Syn. Pl. Aeq. ii. 83 (1865). *E. filicaule* Sch. Bip. in Gray, Proc. Am. Acad. xxi. 384 (1886); Robinson, Proc. Am. Acad. xxxviii. 213 (1902). *Ophryosporus solidaginoides* (HBK.) Hieron. in Engl. Bot. Jahrb. xxix. 4 (1900).— CHIMBORAZO: between Ticsan and Alausí, *Humboldt & Bonpland* (Par., phot. and trac. Gr.). GALÁPAGOS IDS.: Iguana Cove, Albemarle Id., *Snodgrass & Heller*, no. 29 (Gr.).

Var. **typicum**. Leaves at maturity glabrous or nearly so above, puncticulate and sparingly pilose beneath. (Lit., synon., and exsicc. as above.)

Var. BONPLANDIANUM (Sch. Bip.) Robinson. Leaves finely pubescent above, velvety-tomentose beneath.— Proc. Am. Acad. xlii. 27 (1906). *E. syringaefolium* Turcz. Bull. Soc. Nat. Mosc. xxiv. pt. 1, 169 (1851). *Ophryosporus solidaginoides*, var. *Bonplandianus* (Sch. Bip.) Hieron. in Engl. Bot. Jahrb. xxix. 4 (1900), as *Bonplandiana*. — IMBABURA: ravines near Ibarra, *Jameson*, no. 676 (Gr.); in bushy places near Ibarra, alt. 1200 m., *Sodiro*, no. 6/19 (Berl., fragm. Gr.).

38. E. PICHINCHENSE HBK. (see p. 317); Hieron. in Engl. Bot. Jahrb. xxix. 13 (1910).— PICHINCHA: slopes of Mt. Pichincha, *Humboldt & Bonpland*, no. 3116 (Par., phot., Gr.); Quitensian Andes, *Couthouy* (Gr.); in woods on the Volcano Pasochoa, alt. 2900 m., *Sodiro*, no. 6/6a, acc. to Hieron, l. c. [Colombia.]

39. E. SODIROI Hieron. Weak branched undershrub 1-2 m. high; branches curved-ascending, terete, puberulent (hairs minute, jointed, purplish); leaves opposite, petiolate, suborbicular-ovate, obtuse, 3-5 cm. long and wide, few-toothed except at the entire and commonly oblique or strongly asymmetrical base, subglabrous on both surfaces; petiole 9-14 mm. long; corymbs terminal and lateral from the upper axils, together forming a large leafy-bracted flattish-topped inflorescence; heads somewhat glomerate, pedicelled, 25-30-flowered; involucre campanulate; scales about 18, lance-linear, thin, green, loosely villous on the back, subequal, about 2-seriate; corollas white, 4 mm. long, shortly villous toward the limb; the proper tube slender, about equalling the much larger cylindrical throat; achenes upwardly hispid on the angles.— Hieron. in Engl. Bot. Jahrb. xxix. 12 (1900).— PROV. NOT INDICATED: in subandean thickets, *Sodiro*, no. 6/6b (Berl., fragm. Gr.).

40. E. GRACILE, var. EPILOBIOIDES (HBK.) Robinson (see p. 313). *E. caducisetum* DC. Prod. v. 165 (1836); Benth. Pl. Hartw. 201 (1845). *E. caducicetum* Jameson, Syn. Pl. Aeq. ii. 90 (1865).— PICHINCHA: between Quito and the village of Guapulo, acc. to Benth. l. c., as *E. caducisetum*; environs of Quito, acc. to Jameson, l. c., as *E. caducicetum*. [Colombia.]

The Ecuadorian plant mentioned by Bentham is said to have slightly smaller leaves than the original Colombian one. The author has had no opportunity to examine or verify the identity of the Ecuadorian material of this plant. Belonging as it does to a highly technical group it should have further study before its presence in the flora of Ecuador can be regarded as established.

41. E. CUENCANUM Robinson (see p. 241). Slender decumbent

perennial herb, glabrous up to the inflorescence, this beset with short dark stipitate tack-like capitate glands; stem terete, flexuous, very smooth, purplish-brown; leaves opposite, petiolate, ovate, cordate at base, narrowed to an obtusish tip, firmly membranaceous, 2–2.5 cm. long, 1.2–1.6 cm. wide, 3(–5)-nerved from the base; petiole slender, 8–12 mm. long; inflorescence a loose terminal trichotomous few-headed cyme; heads 16–19-flowered, about 7 mm. high, 3–4 mm. in diameter; involucre campanulate, the scales about 18, acute or a little erose, mostly 2-costulate and 3-nerved, 5 mm. long, beset with a few stipitate glands; corollas apparently white, 3.5 mm. long, the proper tube 1.7 mm. long, the throat cylindrical, moderately enlarged, the limb sparingly short-villous; achenes 3 mm. long, pale brown, glabrous: crowned by a disk, pappus-bristles about 14, caducous.— AZUAY, Cuenca, *Sallé* (K., phot. Gr.).

42. E. GLECHONOPHYLLUM Less. Perennial herb or slender undershrub; stem terete, flexuous, usually purplish, at first puberulent, at length glabrate; hairs all very short, some spreading and gland-tipped, others incurved and attenuate; branches opposite, curved-ascending; leaves deltoid-ovate, slender-petioled, more or less caudate-acuminate at the apex, rounded, subtruncate, or open-cordate at the base, thin-membranaceous, serrate to more often rather coarsely crenate, varying greatly in size (1–7 cm. long, 0.8–5 cm. wide), nearly glabrous; petiole 0.4–3 cm. long, pubescent; corymbs terminal, leafy-bracted at base, mostly rather loose; heads about 30-flowered, slender-pedicelled; involucral scales narrowly lanceolate, obtuse to acuminate, subequal, the outer dorsally pubescent; corollas white, with roseate tinge, glabrous except near the slightly hispid limb; proper tube slender, about equalling the distinctly enlarged cylindrical throat; achenes about 2 mm. long, black or nearly so, hispidulous.— Linnaea, vi. 105 (1831); Gay, Fl. Chil. iii. 474 (1847); Reiche, Fl. Chil. iii. 265 (1902), which see for synon.— PICHINCHA: Andes of Quito, *Jameson* (Gr.), *Couthouy* (Gr.). [Chili, Peru.] *E. Sternbergianum* DC. to which some of the Ecuadorian material has at times been referred is a doubtfully separable Peruvian species.

43. E. AZANGAROENSE Sch. Bip. (see p. 315); Hieron. in Engl. Bot. Jahrb. xxix. 13 (1900).— PROV. NOT INDICATED: in subandean thickets, *Sodiro*, no. 6/3, Weddell's narrower-leaved forma α, acc. to Hieron. l. c.; in andean pastures, *Sodiro*, no. 6/5 (Berl., fragm. Gr.), the broader-leaved forma β, acc. to Hieron. l. c.

This species is scarcely distinguishable from the preceding but the writer hesitates to reduce it to synonymy without study of authentic material not at present accessible.

Sect. IV. Conoclinium (DC.) Benth. (see p. 320).

Key to Species.

Leaves deltoid-ovate, cordate, scabrid above; corymbs terminal 44. *E. lamiifolium.*

Leaves ovate-lanceolate, truncate at base, glabrous above; corymbs axillary . . . . 45. *E. Turczaninowii.*

44. E. lamiifolium HBK. Doubtfully herbaceous (Kunth), suffruticose (Jameson), or shrubby and climbing (Sodiro); stems round, striate, densely pubescent, the hairs delicate, attenuate, and articulated; leaves opposite, petiolate, triangular-ovate, shallowly cordate, crenate-dentate, thickish-membranaceous, 3(–5)-nerved from the base, rugose, bullate, and scabrid above, coarsely reticulated and gray-velvety beneath, 6–7 cm. long, 4–5 cm. wide; petiole 2 cm. long; corymb terminal, dense, rounded, 5 cm. in diameter; heads about 36-flowered (26–50 acc. to Hieron. l. c.), 9 mm. long, 5 mm. in diameter; involucre narrowly campanulate, about 4-seriate; scales about 40, acute, lanceolate, pubescent, green or the inner purple-tinged; florets blue (Jameson); achenes about 2 mm. long, nearly or quite glabrous.— Nov. Gen. et Spec. iv. 113 (1820); Jameson, Syn. Pl. Aeq. ii. 88 (1865); Hieron. in Engl. Bot. Jahrb. xxix. 7 (1900).— Prov. not indicated: "In regno Quitensi," *Humboldt & Bonpland* (Par., phot. Gr.). Pichincha: Andes of Quito, alt. 2745 m., *Jameson,* no. 617 (Gr.); in low subandean woods near Quito and Nono, *Sodiro,* nos. 6/8 and 6/13, acc. to Hieron. l. c.

45. **E. Turczaninowii,** nom. nov. Stem suffruticose, round, smooth; branches sticky-pubescent; leaves rather long-petioled, opposite, ovate-lanceolate, acuminate, truncate at base, revolute on the margin, crenate, much wrinkled and glabrous above, white-tomentose beneath; corymbs axillary, nodding; heads many-flowered; involucre 3-seriate, the scales colored, slightly viscid, ovate-oblong, the outer obtuse, the inner longer and acuminate; receptacle conical; corollas smooth, violet; style-branches linear-clavate, thick; style-base bulbous.— *Conclinium rugosum* Turcz. Bull. Soc. Nat. Mosc. xxiv. pt. 1, 168 (1851), not *Eupatorium rugosum* HBK. (1820).— Pichincha: Quito, *Jameson,* no. 209. A species not seen by the writer but from character (here compiled) seemingly of this affinity and distinct.

Sect. V. HEBECLINIUM (DC.) Benth. (see p. 327).

KEY TO SPECIES.

a. Petioles not winged; florets 20–60 *b.*
  b. Stem conspicuously quadrangular ....46. *E. guapulense.*
  b. Stem terete or merely ribbed *c.*
    c. Scales of the involucre about 20, subequal, somewhat ligulate-appendaged; leaves shortly cuneate at the base 47. *E. ovatifolium.*
    c. Scales 30–50, graduated; leaves not cuneate at the base *d.*
      d. Leaves 3-nerved from a point 5–10 mm. above the rounded base; involucral scales lacerate-ciliate toward the tip and bearing a thin membranaceous obtuse appendage; heads 20–25-flowered ....48. *E. recreense.*
      d. Leaves 3-nerved essentially from the cordate base; scales ovate to oval, very obtuse, not appendaged; heads 25–40-flowered ....49. *E. obtusisquamosum.*
a. Petioles winged; florets 100–300 ....50. *E. nemorosum.*

46. E. GUAPULENSE Klatt. Shrubby, climbing, 2–3 m. high, finely and closely rusty-puberulent; branches flexuous, rather sharply quadrangular, the angles rib-like, the faces (at least one pair of them) concave; internodes about 1 dm. long; leaves opposite, long-petioled, broadly ovate, soft, membranaceous, finely serrate almost from the shallowly cordate base to the acuminate tip, 3-nerved from the base, pubescent above, rusty-tomentose beneath; heads 20–30-flowered in paniculately disposed glomerules rather than in a corymb; corollas light-blue; scales of the involucre 3–4-seriate, obtuse, striate; achenes slightly roughened.— Leopoldina, xx. 90 (1884); Hieron. in Engl. Bot. Jahrb. xxix. 14 (1900). *Hebeclinium tetragonum* Benth. Pl. Hartw. 198 (1845); Jameson, Syn. Pl. Aeq. ii. 79 (1865).— PICHINCHA: rather rare, between the village and bridge of Guapulo near Quito, *Hartweg*, no. 1097 (K., phot. Gr.); in moist subandean thickets, *Sodiro*, no. 6/26b, acc. to Hieron. l. c.

47. E. OVATIFOLIUM Hieron. Herbaceous perennial 5 dm. high or more; stem simple and glabrate below, above pubescent, dark-violet, terete; leaves opposite, petiolate, ovate, crenate-dentate except at the acutish or obtusish apex and the shortly cuneate or acuminate base, membranaceous, sparingly villous above, glabrous beneath, 3-nerved, 6 cm. long, 3.5–4 cm. wide; petiole 0.5–3 cm. long, not winged; heads 60–65-flowered, in crowded terminal cymes; pedicels pubescent, sometimes 2 cm. long; involucre broadly campanulate; scales about 20, subequal, linear-lanceolate, shortly acuminate, somewhat ligulate-appendaged and often purplish at the tip; corollas 5 mm. long, the

proper tube about 2 mm. in length, the funnel-formed throat slightly longer; achenes blackish, hispidulous on the angles.— Hieron. in Engl. Bot. Jahrb. xl. 387 (1908).— PICHINCHA: in thickets at the base of Mt. Pichincha, alt. 300 m., *Sodiro*, no. 3, acc. to Hieron. l. c. (whence above char. is here compiled).

48. E. RECREENSE Hieron. Herbaceous and probably perennial, 2–2.5 m. high; leaves opposite, petiolate, round-ovate, very closely and obscurely crenate except at the acuminate and mucronate apex and rounded base, membranaceous, puberulent on the nerves above and over the entire lower surface, the largest 15 cm. long, 13.5 cm. wide; petioles as much as 5 cm. long; heads 20–25-flowered, in dense terminal cyme-like corymbs; pedicels 2–10 mm. long; involucre narrowly campanulate, 4–5-seriate; scales 30–40, the upper part lacerate-ciliate on the hyaline margin but otherwise smooth, the apex provided with a thin obtuse appendage; corollas 3.5 mm. long; achenes glabrous, dark-colored.— Hieron. in Engl. Bot. Jahrb. xl. 389 (1908).— MANABÍ: near Hacienda El Recreo, *von Eggers*, no. 15,148, acc. to Hieronymus, l. c., from whose original description the above character is condensed.

49. E. OBTUSISQUAMOSUM Hieron. Shrub with habit of *E. macrophyllum* and *E. guapulense;* stems subterete or somewhat angulate or flattened, covered with closely matted tawny tomentum; internodes about 1 dm. long; leaves opposite, slender-petioled, round-ovate, broadly cordate, obtusish or slightly acuminate, obscurely crenulate, membranaceous, puberulent and green above, canescent-tomentose beneath, 10–13 cm. long, as broad or slightly broader, 3-nerved somewhat above the base; petioles 2–5 cm. long; heads in a compact terminal corymb, 28–33-flowered; involucre campanulate, about 4-seriate, essentially glabrous, the outer scales broadly ovate, 3–7-costate, brownish-green, narrowly scarious-margined, rounded at the tip, the innermost linear and readily deciduous; receptacle hemispherical, shortly pilose; corollas slenderly tubular, 5 mm. long, the throat slightly and gradually enlarged, glabrous, the limb very short and hispidulous; achenes 1.6 mm. long, dark-brown with pale ribs.— Hieron. in Engl. Bot. Jahrb. xxix. 14 (1900).— PROV. NOT INDICATED: in moist subandean thickets, *Sodiro*, no. 6/20a (Berl., phot. and fragm. Gr.)

50. E. NEMOROSUM Klatt (see p. 327). From this species it has been impossible to separate the Bolivian *E. Rusbyi* Britton, Bull. Torr. Bot. Club, xviii. 334 (1891). Furthermore, although the writer has had no opportunity to examine material of *E. pteropodum* Hieron.

in Engl. Bot. Jahrb. xxix. 15 (1900), its characters, very fully described by its author, coincide in all significant features with those of *E. nemorosum*. The differences are almost entirely in the greater size, of the leaves and the more numerous florets. Neither of these matters seems likely to be of specific value. Klatt's sketch of his type, a rather careful drawing now in the Gray Herbarium, shows the lower leaves more than 25 cm. in length (including the winged petiole, which is 7 cm. long and 1 cm. wide). The blade is about 8 cm. in breadth. It will be seen on comparison that the differences between these dimensions and those given for the lower leaves of *E. pteropodum* by Hieronymus are in no way greater than are usual in individuals of the same species. As to the number of florets, it is true that Klatt, apparently without actual count, roughly estimated it at 100 in his *E. nemorosum*; but a head from Colombian material, collected by Rusby & Pennell and closely matching the type-fragments in Klatt's herbarium, had by careful count no less than 221 florets. The difference between 221-flowered in the case of *E. nemorosum* and 250–300-flowered as stated by Hieronymus for his *E. pteropodum* has no great significance, since variations of much greater latitude have often been observed in individuals of the same species or even in heads of the same individual. It seems strange that Hieronymus, in describing *E. pteropodum* makes no comparison of it with *E. nemorosum* so closely resembling it in all described respects but states that his new plant was not nearly related to any previously described species. The fact, however, that he elsewhere in the same paper lists *E. nemorosum* Klatt and states that it should be placed in Sect. *Hebeclinium* next "*E. macrocephalum* L." — a clerical slip, by which he certainly meant *E. macrophyllum* L., a species with which, however, it has no close affinity, strongly suggests that in some manner Hieronymus has been misled as to the real identity of *E. nemorosum*, and that having referred to it some quite different plant similar to *E. macrophyllum* he therefore failed to notice the identity of his *E. pterophyllum* with the true *E. nemorosum*.— PROV. (CHIMBORAZO?) NOT INDICATED: in tropical and subtropical region near El Puente de Chimbo, *Sodiro*, no. 6/30, acc. to Hieron. l. c., as *E. pteropodum*.

A NEW GEOMETRICAL MODEL FOR THE ORTHOGONAL PROJECTION OF THE COSINES AND SINES OF COMPLEX ANGLES.

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Geometrical constructions for producing plane-vector representations of cosh $(\theta_1 + i\theta_2)$, sinh $(\theta_1 + i\theta_2)$, and hence also cos $(\theta_1 + i\theta_2)$, sin $(\theta_1 + i\theta_2)$, where $(\theta_1 + i\theta_2)$ is a complex argument, or a complex "angle," have been available for some time.[1] These constructions involve a rectangular hyperbola and an associated circle, in one and the same plane, which is the plane of the drawing. By making certain projections in this plane, followed by a rotation through a quadrant, a plane-vector is produced from the origin, corresponding to the complex hyperbolic or circular sine or cosine required. This process is open to the objection that it is somewhat forced and artificial, lacking the simple projective property that a sine or cosine of a real angle possesses in either circular or hyperbolic trigonometry.

More recently, a method of deriving the hyperbolic cosine or sine of a complex angle has been obtained,[2] which has enabled the new three-dimensional model here described to be prepared. In this model, it will be seen that the cosine or sine of a complex angle, either hyperbolic or circular, can be produced, by two successive orthogonal projections on to the X Y plane, one projection being made from a rectangular hyperbola, and the other projection being then made from a particular circle definitely selected among a theoretically infinite number of such circles, all concentric at the origin O, which circles, however, are not coplanar. The selection of the particular circle is determined by the foot of the projection from the hyperbola. This effects a geometrical process which is easily apprehended and visualized; so that once it has been realized by the student, the three-dimensional artifice is rendered superfluous, and he can roughly trace out a complex sine or cosine on an imaginary drawing board, with his eyes closed. The model, however, will be shown to enjoy certain interesting geometrical properties as a three-dimensional structure.

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[1] "Two Elementary Constructions in Hyperbolic Trigonometry," by A. E. Kennelly, Am. Annals of Mathematics, Salem Press, 2d Series. Vol. V, No. 4, pp. 181–184, July, 1904, mainly reproduced in "Tables of Complex Hyperbolic and Circular Functions," by A. E. Kennelly, Harvard University Press, 1914, Figs. 19–22, pp. 165–168.

[2] "Artificial Electric Lines," by A. E. Kennelly, McGraw-Hill Book Co., 1917. Figs. 68 and 69, pp. 120–121.

A photograph of the model is shown in Pl. I. On an ordinary horizontal drawing board 53.5 cm. × 31.8 cm., and 2.2 cm. thick, is a horizontal half rod A B of brass, which merely serves to support the various brass-wire semicircles, and a semihyperbola, in their proper positions. It should be understood that the axis of A B in the X Y plane, on the upper surface of the board, is a line of symmetry for the structure, which, if completed, would be formed by full circles and a complete hyperbola. For convenience, however, only half of the structure above the X Y plane is presented, the omission of the lower half being readily compensated for in the imagination of the beholder.

The eight wire semicircles are formed with the following respective radii, in decimeters: 1.0, 1.020..., 1.081..., 1.185..., 1.337..., 1.543..., 1.810..., and 2.150..., which are the respective cosines of 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, and 1.4 hyperbolic radians, according to ordinary tables of real hyperbolic functions. These successive semicircles therefore have radii equal to the cosines of successively increasing real hyperbolic angles θ_1, by steps of 0.2, from 0 to 1.4 hyperbolic radians, inclusive. All of these semicircles have their common center at the origin 0, in the plane X O Y, of the drawing board. The planes of the semicircles are, however, displaced. The smallest circle of unit radius (1 decimeter), occupies the vertical plane X O Z, in which also lies the rectangular semi-hyperbola X O H. Angular distances corresponding to 0.2, 0.4,.... 1.4 hyperbolic radians, are marked off along this hyperbola at successive corresponding intervals of 0.2. The cosines of these angles, as obtainable projectively on the O X axis are marked off between C and B along the brass supporting halfbar, and at each mark, a semicircle rises from the X Y plane, at a certain angle β with the vertical X O Z plane. This displacement angle is determined by the relation

$$\cos\beta = \frac{1}{\cosh\theta_1} = \operatorname{sech}\theta_1 \qquad \text{numeric} \quad (1)$$

where θ_1 is the particular hyperbolic angle selected. This means, as is well known, that the displacement angle β between the plane of any semicircle and the vertical plane Z O X is equal to the gudermannian of the hyperbolic angle θ_1.

The model is, of course, only a skeleton structure of 8 stages. If it could be completely developed, the number of semicircles would become infinite, and they would form a smooth continuous surface in three dimensions. Along the midplane Z O Y, all of these circles would have the same level, raised 1 decimeter above the horizontal drawing board plane of reference X O Y. The circles would increase in radius without limit, and would cover the entire X O Y plane to infinity, the hyperbola extending likewise to infinity towards its asymptote O S, in the X O Z plane. The actual model is thus the skeleton of the upper central sheet of the entire theoretical surface, near the origin.

The semicircles are also marked off in uniform steps of circular angle. Each step is taken, for convenience, as 9°, or one tenth of a quadrant. Corresponding angular steps on all of the eight semicircles are connected by thin wires, as shown in the Plates.

A front elevation of the model, taken from a point on the O Y axis —15 units from 0, is given in Pl. II. It will be seen that any tie wire, connecting corresponding circular angular points on the semicircles, is level, and lies at a constant height sin θ_2 decimeters above the drawing board. That is, the tie wire that connects all points of circular angle θ_2, measured from O X positively towards O Y, lies at the uniform height sin θ_2 decimeters above the drawing board.

A plan view of the model, taken from a point on the O Z axis, +15 units above 0, is given in Pl. III. It will be seen that each and every semicircle forms an ellipse, when projected on the base plane X O Z. The semi-major axis of this ellipse has length cosh θ_1, where θ_1 is the hyperbolic angle corresponding to that semicircle. The semi-minor axis is

$$\cosh \theta_1 \sin \beta = \cosh \theta_1 \cdot \tanh \theta_1 = \sinh \theta_1$$

from the well known relation that exists between a hyperbolic angle and its gudermannian circular angle; namely

$$\sin \beta = \tanh \theta_1$$

All of these ellipses have the same center of reference O. Any such system, having semi-major axes cosh θ_1, and semi-minor axes sinh θ_1, are well known to be confocal, and the foci must lie at the points +1 and −1 in the X O Y plane, or the points in which the innermost circle cuts that plane.

Moreover, as is indicated in Pl. III, the vertical shadow projections of the tiewires on the reference plane X O Y, form a system of confocal hyperbolas, the foci occupying the already mentioned points +1 and −1, along −X O X. Such a shadow picture is shown in Pl. IV.

Procedure for Projecting cosh $(\pm\,\theta_1 \pm i\theta_2)$

Thus premised, the process of finding the cosine of a complex hyperbolic angle $\theta_1 + i\theta_2$; that is, the process of finding cosh $(\theta_1 + i\theta_2)$ is as follows:

Find the arc C E, Pl. I, from C = +1 along the rectangular hyperbola C E H, which subtends θ_1 radians. The hyperbolic sector comprised between the radius, O C, the hyperbolic arc, and the radius vector O E, on this arc from the origin O, will then include $\frac{\theta_1}{2}$ sq. dm. of area. Drop a vertical perpendicular from E on to O X. It will mark off a horizontal distance O D equal to cosh θ_1. Proceed along the circle which rises at D, in a positive or counterclockwise direction; through θ_2 circular radians, thus reaching on that circle a point G whose elevation above the drawing board is sin θ_2 decimeters. The area enclosed by a radius vector from the origin O on the circle, followed between the axis O C and the circular curve, will be $\frac{\theta_2}{2}\cosh^2\theta_1$ sq. dms.

From G, drop a vertical plummet, as in Pl. II, on to the drawing board. In other words, project G orthogonally on the plane X O Y. Let g be the point on the drawing board at which the plummet from G touches the surface. Then it is easily seen that Og on the drawing board is the required magnitude and direction of cosh $(\theta_1 + i\theta_2)$, in decimeters, with reference to O X as the initial line in the plane X O Y. It may be read off either in rectangular coordinates along axes O X and O Y on a tracing cloth surface as shown in Pl. III, or in polar coordinates printed on a sheet seen through the tracing cloth.

If the circular angle θ_2, i. e., the imaginary hyperbolic angle $i\theta_2$, lies between π and 2π radians, (between 2 and 4 quadrants), the point G will lie on the under side of the plane X O Y, and the projection onto g in that plane must be made upwards, instead of downwards.

If the hyperbolic angle whose cosine is required has a negative imaginary component, according to the expression cosh $(\theta_1 - i\theta_2)$, then starting from the projected point D, we must trace out the circular angle in the negative or clockwise direction, as viewed from the front of the model.

If the real part of the hyperbolic angle is negative, according to the expression cosh $(-\theta_1 \pm i\theta_2)$; then since cosh $-(\theta_1 \mp i\theta_2) =$ cosh $(\theta_1 \mp i\theta_2)$, we proceed as in the case of a positive real component, but with a change in the sign of the imaginary component.

The operation of tracing cosh $(\pm \theta_1 \pm i\theta_2)$ on the X Y plane, thus calls for two successive orthogonal projections onto that plane; namely (1) the projection corresponding to cosh $(\pm \theta_1)$ as though $i\theta_2$ did not exist, and then (2), the projection corresponding to cosh $i\theta_2 =$ cos θ_2 independently of θ_1, except that the radius of the circle, and its plane, are both conditioned by the magnitude of θ_1.

If we trace the locus of cosh $(\theta_1 \pm i\theta_2)$, where θ_1 is held constant, it is evident from an inspection of Pl. III, that we shall remain on one and the same circle, which projects into one and the same corresponding ellipse on the X Y plane. That is, the locus of cosh $(\theta_1 \pm i\theta_2)$ with θ_1 held constant, is an ellipse, whose semi major and minor diameters are cosh θ_1 and sinh θ_1 respectively. If, on the other hand, we trace cosh $(\pm\theta_1 + i\theta_2)$ with θ_2 held constant, we shall run over a certain tie wire bridging all the circles in the model, which tie wire is sin θ_2 dm. above the board, and its projection on the board, in the plane X Y of projection, is part of a hyperbola.

Procedure for sinh $(\theta_1 + i\theta_2)$

It would be readily possible to produce a modification of this model here described, which would enable the sine of a complex angle to be projected on the X Y plane following constructions already referred to.[3] The transition to a new model for sines is, however, unnecessary. It suffices to use the cosine model here described in a slightly different way. One has only to recall that

$$\sinh \theta = -i \cosh \left(\theta + i\frac{\pi}{2}\right) \tag{4}$$

or

$$\sinh (\theta_1 + i\theta_2) = -i \cosh \left\{\theta_1 + i\left(\theta_2 + \frac{\pi}{2}\right)\right\} \tag{5}$$

Consequently, in order to find the sine of a complex hyperbolic angle, we proceed on the model as though we sought the cosine of the same angle, increased by $\frac{\pi}{2}$ radians or 1 quadrant, in the imaginary or circular component. We then operate with $-i$ on the plane vector so obtained; i. e., we rotate it through 1 quadrant in the X Y plane and in the clockwise direction. An equivalent step is, however, to rotate the X and Y axes of reference in that plane through 1 quadrant in the reverse or positive direction. That is, we may omit the $-i$ operation, if, in dealing with sine projections, we treat O Y as an O X axis, and $-$O X as an O Y axis, or read off the projections on the X Y plane to the $-$Y O Y axis as initial line.

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[3] Artificial Electric Lines, loc. cit. Fig. 69, page 121.

The only difference, therefore, between projecting the cosine and the sine of a complex hyperbolic angle in the model, is that in the latter case the circular component is increased by one quadrant and the projected plane vector is read off to the O Y reference axis as initial line. The model thus gives the projection of either cosh $(\pm\,\theta_1 \pm i\theta_2)$ or sinh $(\pm\theta_1 \pm i\theta_2)$ within the limits of $+1.4$ and -1.4 for θ_1, and for θ_2 between the limits $+\infty$ and $-\infty$. For accurate numerical work, reference would, of course, be made to the charts and Tables of such functions already published,[4] and which enable such functions to be obtained either directly or by interpolation, for all ordinary values of θ_1 and θ_2.

Procedure for Projecting cos $(\pm\,\theta_1 \pm i\theta_2)$.

The model enables either the cosine or sine of a hyperbolic complex angle to be projected as a complex quantity or plane vector on the X Y plane. It may also be used for projecting the cosine of a circular complex angle.

Since
$$\cos\beta = \cosh i\beta \tag{6}$$

we have, if $\beta = \pm\theta_1 \pm i\theta_2$,

$$\begin{aligned}\cos(\pm\,\theta_1 \pm i\theta_2) &= \cosh\ (\pm\, i\theta_1 \mp \theta_2) = \cosh(\mp\,\theta_2 \pm i\theta_1)\\ &= \cosh-(\pm\,\theta_2 \mp i\theta_1) = \cosh(\pm\theta_2 \mp i\theta_1)\end{aligned} \tag{7}$$

In projecting the circular cosine of a complex angle, therefore, we exchange the imaginary and real components, changing the sign of the latter in so doing. We then proceed as though the angle were hyperbolic. The model permits of the projection of cos $(\pm\,\theta_1 \pm i\theta_2)$ between the limits of $+\infty$ and $-\infty$ in θ_1, and the limits of $+1.4$ and -1.4 in θ_2.

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[4] Chart Atlas of Complex Hyperbolic and Circular Functions, by A. E. Kennelly, Harvard University Press, 1914.

Procedure for Projecting sin $(\pm\,\theta_1 \pm i\theta_2)$.

Since
$$\sin\beta = \cos\left(\beta - \frac{\pi}{2}\right) \tag{8}$$

we have by substituting $\beta = \pm\theta_1 \pm i\theta_2$

$$\begin{aligned}\sin(\pm\,\theta_1 \pm i\theta_2) &= \cos\left\{\left(\pm\,\theta_1 - \frac{\pi}{2}\right) \pm i\theta_2\right\}\\ &= \cosh\left\{\pm\,\theta_2 - i\left(\pm\,\theta_1 - \frac{\pi}{2}\right)\right\}\\ &= \cosh\left\{\pm\,\theta_2 + i\left(\frac{\pi}{2} \mp \theta_1\right)\right\}\end{aligned} \tag{9}$$

This procedure differs only from that for cos $(\pm\theta_1 \pm i\theta_2)$ in altering the imaginary $i\theta_1$ by one quadrant.

Relations between Complex Hyperbolic and Circular Angles.

The projective relations above stated for the cosines and sines of both complex hyperbolic and circular angles indicate that while hyperbolic angles relate to rectangular hyperbolic sectors, and circular angles relate to circular sectors, a complex angle relates to an association of a hyperbolic and a circular sector. If the complex angle is hyperbolic, its real part relates to a hyperbolic, and its imaginary part to a circular, sector. On the other hand, if the complex angle is circular, its real part relates to a circular, and its imaginary part to a hyperbolic, sector. Complex hyperbolic trigonometry and complex circular trigonometry thus unite in a common geometrical relationship.

Geometrical Nature of a Complex Hyperbolic Angle.

In the engineering theory of electric conductors carrying alternating currents, complex hyperbolic angles naturally present themselves.[5] The question naturally arises as to how such complex angles may be realized and visualized geometrically. There is no difficulty in the realization of a real hyperbolic angle. The difficulty only arises with the addition of the imaginary component. It is suggested that the new model here described permits of this realization, and thus constitutes an embodiment of a complex hyperbolic angle.

---

[5] The Application of Hyperbolic Functions to Electrical Engineering Problems, by A. E. Kennelly, University of London Press, 1912; also Artificial Electric Lines, McGraw-Hill Book Co., 1918.

The model only purports to skeletonize part of the upper sheet of three-dimensional surface which it includes. The half beneath the X Y plane is omitted. It seems likely, moreover, that for the purpose of analytical completeness, the model should be repeated from O to infinity above the board along the $-Y$ axis. That is, it should *probably have the* X O Z *plane as a plane of symmetry*, with a rectangular hyperbola at each end of the vertical circle in that plane, and with a series of circles bending away from the vertical on each side of that plane. In the fully developed structure, each of the principal planes X O Y, X O Z, Y O Z would be a plane of symmetry. So far as projective requirements are concerned, however, this image reduplication of the model about the X Z plane is superfluous.

Examples in the Use of the Model.

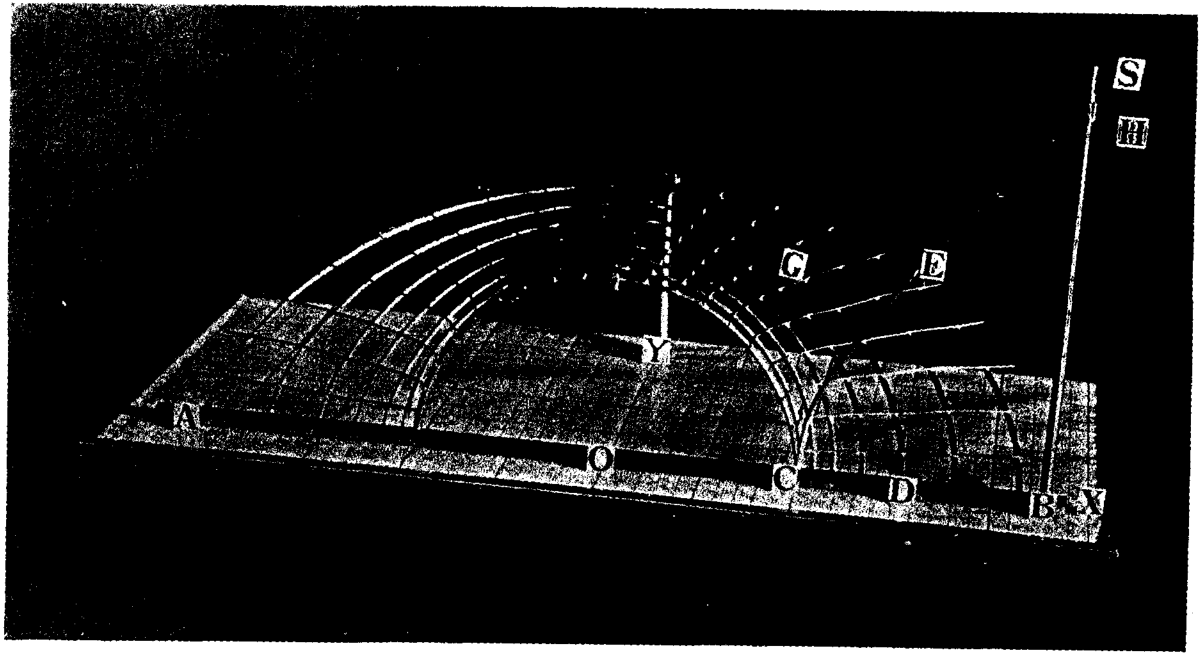
This model was designed by the writer to facilitate the conception, definition and realization of complex angles, and not for evaluating their functions; because the Tables and Charts already published are much more to the purpose of obtaining numerical values. Nevertheless, the following simple examples from the Tables may readily be checked by the reader, with reference to Pls. III and IV, but to a low degree of precision only:

$$\begin{array}{l}
\cosh\,(\ 1 + i\underline{0.6}) = 0.90700 + i0.95076 = 1.31400 \angle 46^\circ.349 \\
\sinh\,(0.8 - i\underline{0.5}) = 0.62799 - i0.94571 = 1.13522 \overline{\diagdown} 56^\circ.414 \\
\cos\,(\underline{0.5} + i0.5) = 0.79735 - i0.36847 = 0.87837 \overline{\diagdown} 24^\circ.803 \\
\sin\,(\ 0 + i1.2) = 0 \qquad\qquad + i1.50946 = 1.50946 \angle 90^\circ
\end{array}$$

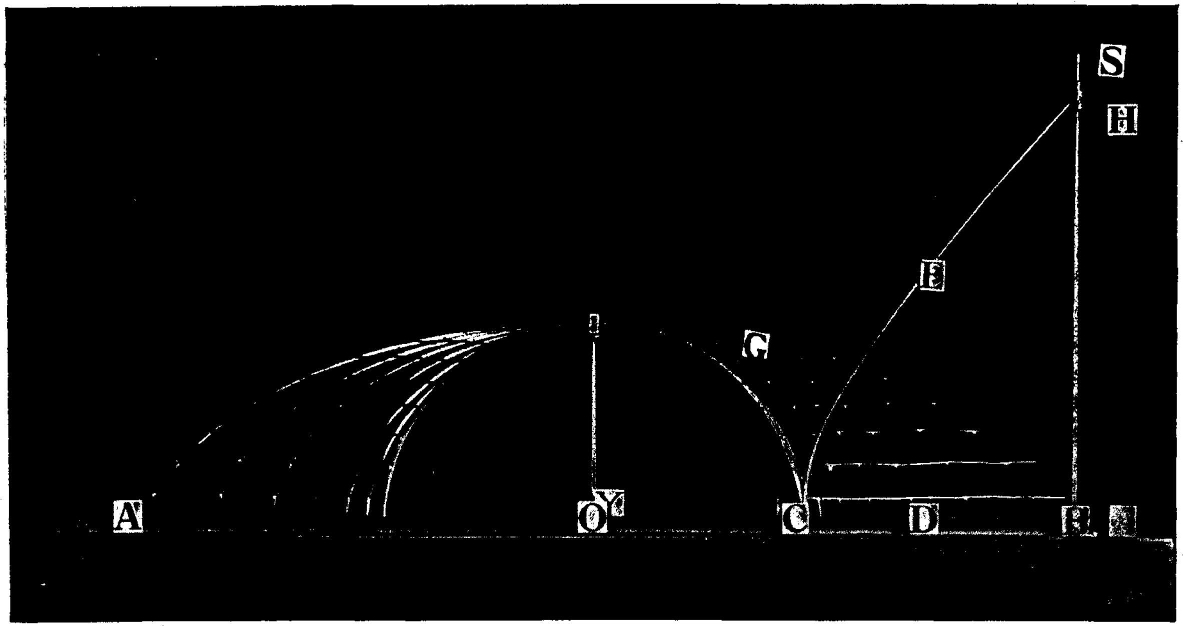
Underscored numerals represent decimal fractions of a circular quadrant. Thus $\underline{0.6} = 54^\circ$.

Acknowledgment.

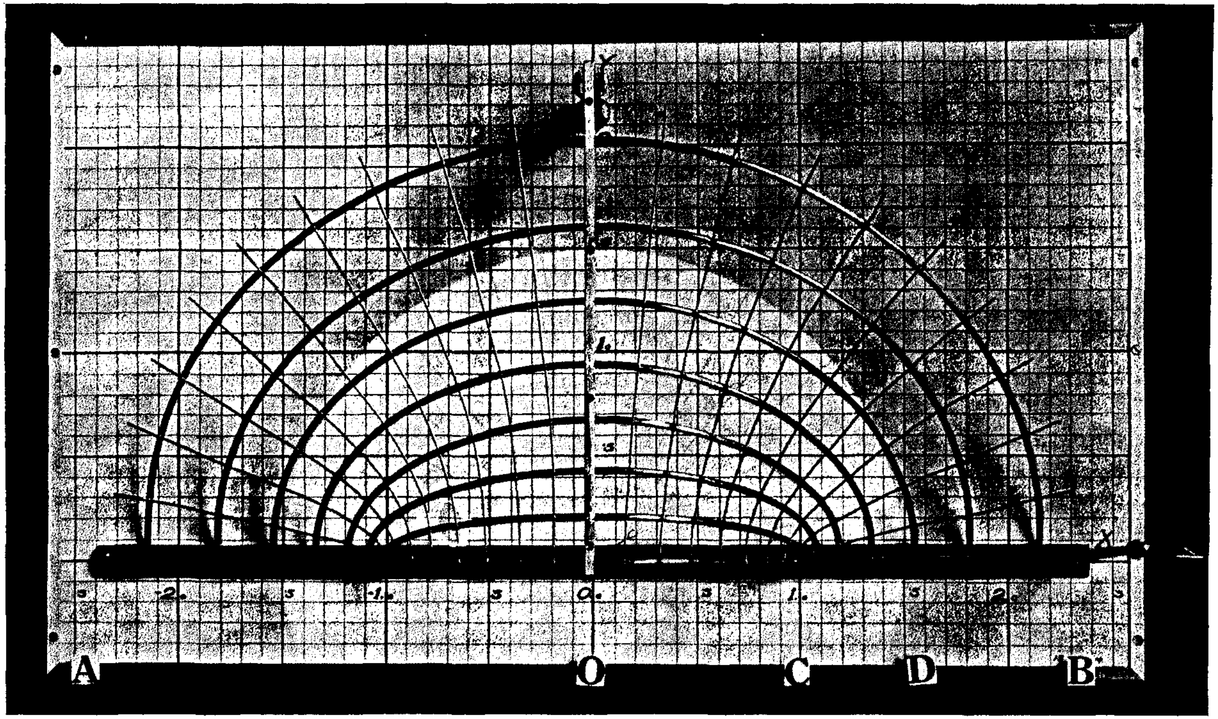
The writer is indebted to his assistant, Mr. Edy Velander, who, with care and skill, has constructed the model shown in the Plates, and also to his colleague Prof. Louis Derr, for the photographs from which the accompanying Plates have been produced.


S
H
G
E
Y
A
O
C
D
B
X

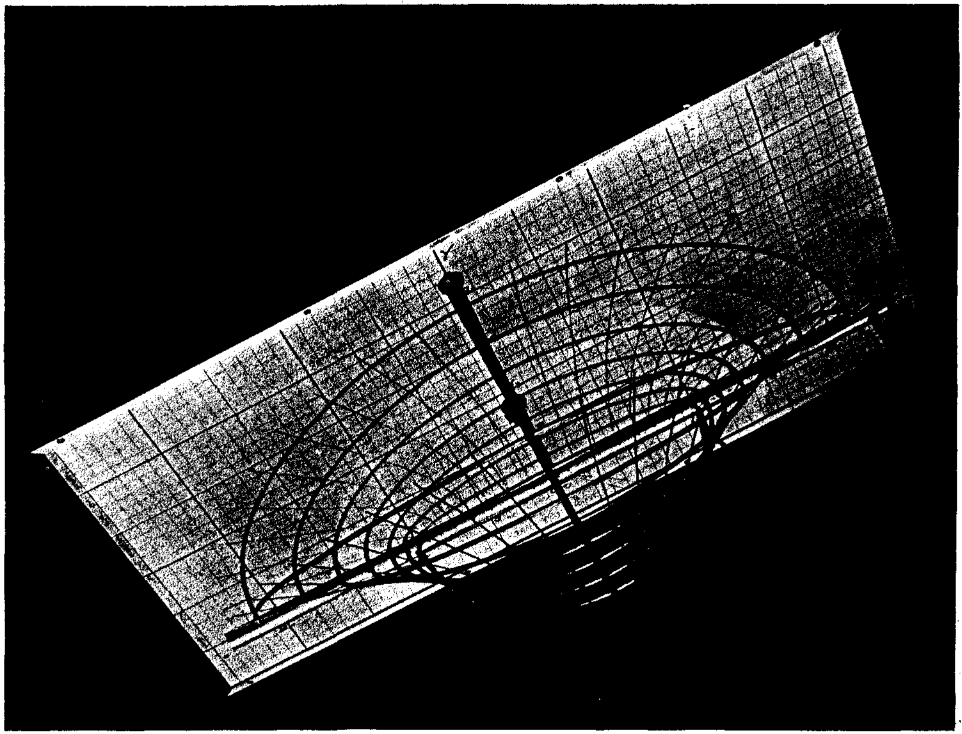
Photograph of Model.



Front Elevation of Model from a point on the OY axis —15 units (decimeters) from O.


Y
X
.5
-2.
.5
-1.
.5
0.
.5
1.
.5
2.
.5
1.
.5
A
O
C
D
B

Plan View of Model, taken from a point on the OZ axis + 15 units (decimeters) from O.



Shadow photograph of Model on the XOY plane, showing the confocal Ellipses and Hyperbolas, produced by orthogonal projection on that plane.

Proceedings of the American Academy of Arts and Sciences.

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RECORDS OF MEETINGS, 1918–19.

BIOGRAPHICAL NOTICES.

OFFICERS AND COMMITTEES FOR 1919–20.

LIST OF THE FELLOWS AND FOREIGN HONORARY MEMBERS.

STATUTES AND STANDING VOTES.

RUMFORD PREMIUM.

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(TITLE PAGE AND TABLE OF CONTENTS.)

RECORDS OF MEETINGS.

One thousand and seventy-fourth Meeting.

OCTOBER 29, 1918.— SPECIAL MEETING.

A special meeting was held at the House of the Academy at 8.30 P.M. for the purpose of giving a reception to the British Educational Mission to the United States, composed of the following persons:— Dr. Arthur Everett Shipley, Sir Henry Miers, the Rev. Edward Mewburn Walker, Sir Henry Jones, Dr. John Joly, Miss Caroline Spurgeon and Miss Rose Sidgwick.

Invitations to the reception were sent to the Presidents and Deans of all the New England Colleges and to Mr. and Mrs. Charles Storrow, Mr and Mrs. W. F. Bentinck-Smith, Mr. and Mrs. S. C. Murfitt, the Earl of Camperdown, Mr. and Mrs. Charles Stewart, and Mr. and Mrs. McKibbin. One member of the family of each Fellow of the Academy was also invited. There were about two hundred persons present.

One thousand and seventy-fifth Meeting.

NOVEMBER 13, 1918.— STATED MEETING.

The Academy met at its House.

The PRESIDENT in the Chair.

There were thirty Fellows and one guest present.

The following letters were presented by the Corresponding Secretary:— from Brooks Adams, Edward Capps, C. A. Coolidge, E. B. Delabarre, W. H. P. Faunce, E. W. Forbes, Morris Gray, I. M. Hays, G. L. Hendrickson, E. C. Hills, A. M. Huntington, T. N. Page, Leighton Parks, Endicott Peabody, F. G. Peabody, H. B. Phillips, Rudolph Schevill, D. L. Webster, accepting Fellowship; from Gamaliel Bradford, declining Fellowship. The Corresponding Secretary read a letter from Professor F. H. Newell on behalf of the Committee on Reconstruction Problems of the National Research Council suggesting the coöperation of scientific societies in the study of post-bellum problems. This letter was referred to the Council.

The Chair announced the following deaths:— Grove Karl Gilbert, Class II., Section 1; Frederick Remsen Hutton, Class I., Section 4; Charles Card Smith, Class III., Section 3; George Mary Searle, Class I., Section 1; Arlo Bates, Class III., Section 4; William Leslie Hooper, Class I., Section 2; James Jackson Putnam, Class II., Section 3; Samuel Wendell Williston, Class II., Section 1; and Sir James Augustus Henry Murray, Foreign Honorary Member in Class III., Section 4.

Biographical notices were presented as follows: Francis Humphreys Storer by Charles W. Eliot, Francis Blake by Charles R. Cross, and William Bullock Clark by B. K. Emerson.

The Rumford Medals were presented to Professor Percy Williams Bridgman, of Cambridge, Mass., for his Thermodynamical Researches at Extremely High Pressures.

Professor Cross, Chairman of the Rumford Committee, stated the grounds on which the award was made, as follows:—

"The researches of Professor Bridgman for which the Academy has awarded to him the Rumford Premium comprehend an extended and remarkable investigation of the thermodynamical properties of water and to a certain extent, of other liquids, under unprecedentedly great pressures. This involved a study of the relation between temperatures, volumes, and pressures, the latter through an extremely great range.

The position of these studies in the history of scientific research will be best appreciated through a brief reference to historical data. In 1661 Boyle discovered the "Law" now bearing his name that the volume of a gas through a great range varies inversely as the pressure upon it. Mariotte in France in 1676 independently made and published the same discovery. Charles and, shortly afterward, Gay Lussac in 1802 discovered the facts regarding the expansion of ordinary gases with rise of temperature, *viz*: that for different gases for each degree through a large range this is the same definite fraction of the original volume. This fact became known as the "Law of Charles" or of Gay Lussac. Further study of the subject was made by Dulong and Arago, in 1829, with the design of ascertaining the limits within which the so-called laws were exact and later, by a great experimenter, Regnault, in 1847, through whose ingenious processes highly important deviations from the laws at high pressures (up to 27 atmospheres) were found. Studies were made by him on the pressure of steam as related to temperature and also measurements of the expansion of mercury and some other liquids. Amagat in his researches in 1869 and the following years reached pressures up to 3,000 atmospheres. The liquefaction and solidification of the so-called "permanent gases" by Cailletet and Pictet and the related studies by Andrews of the "critical point" were also most important.

Referring to liquids, the compressibility of water, that is, the relation of volume to pressure, was first measured by Jacob Perkins of Newburyport, a member of this Academy in 1820, and later Oersted and others investigated the subject further. Amagat, who worked also in this field, employed the highest pressures by far that had been reached even up to 3,000 atmospheres, as already remarked, and Tammann raised this to 3,500 atmospheres. But, even before reaching these extreme pressures the leakage of the packing and the joints of the piezometer became quite intolerable. Also James Thomson and his brother William had shown in 1850 the effect of pressure in lowering the melting point of water.

This rapid sketch will indicate sufficiently well for present purposes what was the condition of this branch of physics at the beginning of the work of Mr. Bridgman.

About ten years since Mr. Bridgman began an extended series of experiments upon the relations between the pressure, volume and temperature which obtain with different substances, particularly liquids and solids. Previous experimenters as just stated had found it impossible to maintain pressures greater than 3,000 atmospheres on account of the apparently insuperable difficulty from leakage at the joints of the movable parts of the compression apparatus. By a most ingenious device Mr. Bridgman succeeded in overcoming this defect so completely that he was able to subject the substance to be studied to pressures up to 20,000 atmospheres, or even higher, without serious difficulty. This accomplished, he was able to enter upon a series of researches upon the phase relations (volume-pressure-temperature) of water in its liquid and solid states as well as those of certain other liquids, with results which widely transcend in extent and value all that had been reached by earlier researchers. He designed a direct primary pressure gauge of very simple construction, and secondary gauges based upon the change of resistance of mercury or manganin calibrated by the former were also employed.

A brilliant series of experiments was made by which were studied the thermodynamic properties of liquid water up to 80 degrees temperature and 20,000 kg/cm^2 pressure, and also those of five forms of ice, that is, forms which have different and novel phase relations. Two of these were newly discovered by Mr. Bridgman.

Studies were made of various other liquids and the changes of phase under pressure of eleven chemically different substances were likewise ascertained.

The interesting and important fact is indicated by the curves of Professor Bridgman that for the passage from the solid to the liquid state there is no critical point, a complete difference from that which occurs on the passage from the liquid condition to that of vapor.

In later papers a study of polymorphic changes is described with important results, and an investigation of the electric properties of metals under pressure, which subject is still occupying Professor Bridgman's attention, except as it has been interrupted by duties incident to the Great War.

Moreover, Professor Bridgman has not confined himself to pure experimentation, but has considered analytically the thermodynamics of the subject which he has investigated.

The Rumford Committee considers itself fortunate to have been able by its grants to aid the researches of Professor Bridgman and so to fulfill the desire of the Supreme Court of the Commonwealth that appropriations made from the Rumford Fund for researches may lead to the award of the Rumford Premium.

The presentation of the medals was made by the President to Dr. Bridgman, who expressed his appreciation of the honor.

The following motion was made by Mr. Brooks Adams: — That the Chair appoint a Committee of five, with power to add to its number and to fill vacancies, to consider and report on the effect which the war has had upon the attitude of science.

First: Toward the use and preservation of food and the conservation thereof; and

Second: Toward the use and conservation of fuel, and the development of additional supplies thereof.

The motion was debated by Professors E. B. Wilson and W. T. Sedgwick and was not carried.

Vice-President Davis offered a resolution calling on various learned Societies to join with the Academy in urging the establishment of a League of Nations.

It was

Voted, That the above motion be laid on the table.

The resignation of the Recording Secretary was announced and referred to the Council.

The following Communication "Recent Advances in Stellar Photography" by Professor S. I. Bailey was announced for the meeting, but because of his sudden illness, only a portion of the communication was given.

The following papers were presented by title: — 1. On the Theory of Reed Instruments. 2. Note on the Ballistic Resistance Function. 3. On the Dynamics of the Rifle Shot from the Shoulder. By A. G. Webster.

One thousand and seventy-sixth Meeting.

December 11, 1918. — Stated Meeting.

The Academy met at its House.

The President in the Chair.

There were forty-seven Fellows present.

The Corresponding Secretary presented a letter of acceptance of Fellowship from Walter Hines Page.

The Chair announced the following deaths: Charles R. Van Hise, Class II., Section 1; Franklin Paine Mall, Class II., Section 3; Andrew D. White, Class III., Section 2, Fellows; and Adolf, Ritter von Baeyer, Class I., Section 3; Hermann, Graf zu Solms-Laubach, Class II., Section 2; Angelo Celli, Class II., Section 4; and Emil von Behring, Class II., Section 4, Foreign Honorary Members.

The President announced that to his gratification Dr. Bigelow had withdrawn his resignation as Recording Secretary.

It was Voted,

That the thanks of the American Academy of Arts and Sciences be given to Mr. Charles Stewart, Miss Freeman, and the J. L. Hammett Co. for their courtesy in loaning to the Academy the British and American flags at the recent reception offered to the British Educational Mission.

The following vote of the Council was reported : —

That the Librarian be requested to deposit the following volumes in the Library of the Massachusetts Historical Society, as a Special Deposit, subject to recall to the Library of the Academy by a vote of the Council:—

	Vols.
Connecticut. Acts and Laws. 1750–[52]. New London, 1750. F.	1
Connecticut. Acts and Laws. 1784. New London, 1784. F.	1
Great Britain. Abridgment of Public Statutes, by John Gay, L., 1739	2
Massachusetts. Acts and Laws. 1692–1764. Bost., 1759–64. F. [With Notes by Bowdoin].	1
Massachusetts. Acts and Laws. 1692–1755. Boston, 1742–55. F.	1
Massachusetts. Acts and Laws. 1780–85. Boston, 1781–[85]. F.	1
Massachusetts. Laws [1785–87]. Boston, 1786. Q.	1
Massachusetts. Journal of House, 1761–62, 1770–71, 1771–72, 1772–73, 1773–74	5
Massachusetts. Perpetual Laws. 1780–1800, 1801. O.	3
Massachusetts. Private and Special Statutes, 1780–1805, Boston, 1805	3
Massachusetts. Resolves, 1785–87, Boston, 1785–87	1
New York. Laws, 1691–1773, N. Y., 1774	1

NEWSPAPERS

Boston Chronicle, 1767–70	3
Boston Daily Advertiser, July, 1823–June, 1824	2
Boston Gazette, 1802	1
Boston News Letter, and Boston Post Boy, 1760–61	1
Boston Newspapers (miscellaneous) 1763–74, 76–84, 86 (Jan.–Aug.)	21
Boston Post Boy, 1759–60	1
Columbian Centinel, 1794–95, 1802	2
Federal Orrery, 1794–96	1
Massachusetts Centinel, 1786–88	2
Massachusetts Spy, 1784–85, 1788–1808, 1823–30	23
New England Palladium, 1802	1
New York Herald, 1795–96	1
	80

Vice-President Davis' motion in regard to a petition in favor of a League of Nations having been taken from the table, it was withdrawn by him with the understanding that it would be replaced by a petition to be signed by members of the Academy as individuals.

The following communication was given, Professor A. G. Webster, "A Student's Recollections of Berlin under Three Kaisers, with Glances at Paris."

The following paper by Thomas Willing Balch was presented by title: "The Origin of the Name Metz."

The meeting then adjourned to the Reception Room where an informal exhibition of much interest was held.

One thousand and seventy-seventh Meeting.

JANUARY 8, 1919.— STATED MEETING.

The Academy met at its House.

The PRESIDENT in the Chair.

There were thirty-three Fellows and one guest present.

A letter was presented from Professor W. R. Thayer, Corresponding Secretary of the Massachusetts Historical Society, acknowledging the deposit of volumes from the library of the Academy.

The Corresponding Secretary reported a vote of the Council that it is inexpedient to take further action at this time in regard to the nomination of Resident Associates.

The President commented briefly on the death of Ex-President Roosevelt and announced the following deaths:—Timothy Dwight, Class III., Section 2; Walter Hines Page, Class III., Section 4; John Duer Irving, Class II., Section 1., who was elected May 9, 1917, and died in France, July 20, 1918, never having accepted Fellowship.

The following Communications were presented:—

Dr. Thomas Willing Balch, "The Origin of the Name Metz."

Dr. Frederick C. Shattuck, "Epidemics of Influenza and Other Diseases."

Prof. Roland Thaxter, "On New Laboulbeniales from Chile and New Zealand."

The meeting then adjourned.

One thousand and seventy-eighth Meeting.

February 12, 1919.—Stated Meeting.

The Academy met at its House.

The President in the Chair.

There were forty-one Fellows and two guests present.

The President announced the following deaths:—Wallace Clement Sabine, Class I., Section 2; Clarence John Blake, Class I., Section 2; Edward Charles Pickering, Class I., Section 1.

The Librarian announced the gift of thirty-six volumes from the estate of Charles Card Smith, which have been added to the catalogue and placed on the shelves.

The following Communications were presented:—

Prof. E. K. Rand, "Supposed Autographa of Iohannes Scottus."

Prof. Barrett Wendell, "Dreams as a Factor in Literature."

Prof. B. L. Robinson, "Some Recent Investigations on South American Plants."

The following paper was presented by title:—Dr. A. E. Kennelly, "A New Geometrical Model for the Orthogonal Projection of the Cosines and Sines of Complex Angles."

The meeting then adjourned.

One thousand and seventy-ninth Meeting.

MARCH 12, 1919.—STATED MEETING.

The Academy met at its House.

The PRESIDENT in the Chair.

There were forty-three Fellows and two guests present.

The Council announced that it had adopted the recommendations in the following report on the more frequent use of the House of the Academy.

Joint report of a Special Committee composed of Professor Barrett Wendell, Professor G. F. Moore, Professor W. T. Sedgwick and the House Committee.

It is recommended that the following measures be adopted:—

There shall be a series of not more than four "Open Meetings" yearly. Notices to be sent to Fellows and invitations to a selected list of young men approximately eligible for membership, and such others as the Officers of the Academy may desire. Each Fellow and guest shall have the right to bring one lady. The meetings shall be held at, say, four P.M., and shall consist of a prepared address of not more than thirty or forty minutes on some topic of current literary, scientific or educational interest, to be presented by a member of the Academy or some distinguished visiting stranger; to be followed by light refreshments in the upper room, where anyone who could not come earlier will be welcome.

It is suggested that a committee of ladies, selected from the wives of members, be appointed to take charge of the refreshments and reception after the address.

No china, etc., shall be purchased until the success of these meetings is assured. Such articles are to be provided by a caterer for the first few meetings.

A special committee shall be appointed to select the speakers, who should be chosen to represent the different classes of the Academy.

The general arrangement for these meetings is to be left in the hands of the Committee on Meetings.

As soon as the House Committee can secure latch keys, a notice shall be sent to the Fellows that they can obtain keys by applying to the Assistant Librarian. A list shall be kept of all Fellows holding latch keys.

Members making use of the Academy Building shall be invited to bring their friends, and are expected to inscribe the names of their guests in a stranger's book to be provided for the purpose, and kept in the small committee room.

(signed) G. R. Agassiz,
For the Committees.

The Chair appointed the following Councillors to act as Nominating Committee, and announced that he should not be a candidate for re-election, expressing his thanks for the highest honor he had ever received:—

Harvey N. Davis, of Class I.
Benjamin L. Robinson, of Class II.
Fred N. Robinson, of Class III.

On recommendation of the Council, the following appropriations were made for the ensuing year:—

From the income of the General Fund, $8,600, to be used as follows:—

for General and Meeting expenses	$ 700.00
for Library expenses	3,300.00
for House expenses	2,000.00
for Treasurer's expenses	800.00
for printing biographical notices	300.00
for use of the Publication Committee	1,500.00

From the income of the Publication Fund, $3,360.08, to be used for publication.

From the income of the Rumford Fund, $3,188.20, to be used as follows:—

for Research	$1,000.00
for Books, periodicals and binding	300.00
for Publication	600.00
for use at the discretion of the Committee	1,288.20

From the income of the C. M. Warren Fund, $800, to be used at the discretion of the Committee.

The following preliminary notice was presented by Dr. Francis H. Williams.

During the war, Mr. Elof Benson invented a method for locating submarine objects, depending upon sound shadows. While I was trying to assist him to get recognition for his method, we both became interested in devices for receiving signals under water and in the air, one of which was a coil made of strips of soft iron covered with a vortex winding of insulated copper wire. When this was connected with an amplifier, we found that it responded not only to electric and magnetic waves, but also to the voice. We failed to understand, nor did any among the physicists to whom we demonstrated our work explain *why* the coil responded to the voice.

Finally, one of us attempted to find this explanation, and devised experiments to that end with a modified coil. As one result of these experiments, I desire to state my belief that sound waves can disturb a magnetic field and thus set up a current in a near-by coil.

I hope at some future time to have an opportunity to present to the Academy an account of these experiments.

The following Communications were presented:—

Professor Ephraim Emerton, "The First European Congress."

Professor Cornelius Van Vollenhoven, "Holland's International Policy."

The following paper was presented by title:

"A New Mixed Problem in Partial Differential Equations arising from the Theory of Wind Instruments." By Arthur G. Webster.

The meeting then adjourned.

One thousand and eightieth Meeting.

April 9, 1919.— Stated Meeting.

The Academy met at its House.

The President in the Chair.

There were thirty-four Fellows and one guest present.

The Corresponding Secretary presented the following letters:— from George E. Hale, of the National Research Council, inviting the Academy to participate in the organization of a division of Foreign Relations, from the Secretary of the League for the Preservation of American Independence, asking the coöperation of the Academy; from the Harvard Biblical Club, thanking the Academy for the use of the Committee Room during the past year.

The Chair announced the death of John Wallace Baird, Fellow in Class II., Section 3.

Dr. Arthur A. Noyes was appointed to represent the Academy as a member in the Division of Foreign Relations of the National Research Council.

The President referred the proposed alteration of the Statutes to a Committee consisting of E. B. Wilson, H. W. Tyler and E. V. Huntington.

The following Communications were presented:—

Prof. E. S. Morse, "Observations on Living Lamellibranchs of New England."

Prof. A. E. Kennelly, "A New Geometrical Model for the Orthogonal Projection of the Cosines and Sines of Complex Angles."

Dr. G. M. Allen, "Some Habits of Cave-frequenting Bats."

The meeting then adjourned.

One thousand and eighty-first Meeting.

May 7, 1919.— Special Meeting.

The Academy met at its House.

The President in the Chair.

There were thirty-four Fellows and two guests present.

Professor Charles R. Cross, Chairman, on behalf of the Rumford

Committee, stated the grounds for the award of the Rumford Premium to Professor Theodore Lyman, of Cambridge, as follows:—

The Rumford Premium has been awarded by the Academy to Professor Lyman "for his researches on light of very short wave length."

If we view the spectrum with the red at our left and the violet at our right, the lengths of the ether waves corresponding to the different colors in the order given by Newton, red, orange, yellow, green, blue, indigo, violet, run from longer to shorter as is the case with the sound waves of the piano from the bass strings at the left to the acute strings at the right. The unit in which to measure these wave lengths most conveniently is the tenth-meter or Ångstrom unit (Å) which is 10^{-10} meters. In terms of this unit the wave length of the extreme red rays at the black Fraunhofer line A of the spectrum is 7,600. That of the violet rays at the extreme right of the spectrum at the black Fraunhofer line H is 3,969. For over one hundred and twenty-five years after Newton's first writing these were tacitly assumed to be the extreme limits of radiation. In 1800, Sir William Herschel discovered that there were radiations affecting the thermometer outside of the visible spectrum beyond the red, a fact which, however, was received with much skepticism for some time, and his son, Sir John Herschel, forty years later discovered the existence of "cold" Fraunhofer lines in the infra-red, as this region has come to be called. In 1880, Captain Abney by photographic methods of his own devising succeeded in detecting and measuring infra-red rays in the solar spectrum as far down as 10,000 Å. For this discovery, together with certain allied work he was awarded the Rumford Medal of the Royal Society of London. Shortly after this (1881) Professor Langley of the Allegheny Observatory, using a newly devised thermometric instrument invented by him, the bolometer, based on the change in electrical resistance sustained by a platinum strip under changing temperature, demonstrated the existence of an infra-red spectrum (solar) down to 20,000 and later to 55,000 Å the Fraunhofer lines in which he mapped to that limit, while detecting the presence of sensible radiation down to 180,000 Å. Because of this research he was awarded the Rumford Medal of the Royal Society and, in the same year, the Rumford Medal of the American Academy. This is the only case in which both of these awards have been made to the same person. The existence of far longer infra-red ether waves has been proved by Rubens and his students in Berlin, among whom were several Americans, two of these being E. F. Nichols and R. W. Wood, both of whom have received the Rumford Medal of this Academy. An indirect method, that of measuring the "rest-strahlen" was chiefly employed. These go down to one-third mm. These longest "heat waves" almost reach the length of the shortest Hertz waves, which are only about 2 mm. long and whose length increases up to thousands of feet as with those used in radio-telegraphy.

At about the same time that the elder Herschel discovered the existence of infra-red rays, Ritter and Wollaston showed that certain silver salts were acted upon photographically by previously unknown radiations outside of the violet, the ultra-violet rays, and E. Becquerel demonstrated their photographic action in 1842 as existing up to 3,400 Å. in the solar spectrum. Stokes's discovery of fluorescence in 1851 enabled him by this new method to detect ultra-violet radiations of wave-length 3,000 Å in sunlight, and up to 1850 Å in the light of the electric spark between metal electrodes. In the study of these very highly refrangible rays Stokes was obliged to use prisms and lenses of quartz on account of the great absorptive power of glass for such radiations. Cornu reached the same limit by photography.

A most serious obstacle to the further prosecution of researches of this character was the highly absorptive power of atmospheric air for these extreme rays even in thin layers. This set a limit to further advances by known methods.

Victor Schumann, somewhat before 1890, undertook to overcome the difficulty by constructing a vacuum spectroscope and camera. In this, the rays from an electric discharge *e. g.*, through hydrogen in a vacuum tube with a fluorite window, passed through an inclosed optical train of prism and lenses of fluorite, which substance he had found to be more transparent to higher radiations than quartz. The rays passed through a rarefied atmosphere of hydrogen on their way to the photographic plate instead of through air at the ordinary density. Under these conditions it was found that radiations far above any previously detected were recognized on the photographic plate. Schumann also employed an emulsion of his own invention in order to secure better action with such short waves as those he was to deal with, which were strongly absorbed by gelatine. As a result he obtained excellent photographs of hydrogen lines which he believed to have a wave length as short as 1,000 Å. He also mapped the lines of various other gases. But manifestly using as he did a prismatic spectrum it could not be certain first that higher radiations were not absorbed by the fluorite and second that the wave-lengths of those which were transmitted by it were correctly estimated. In fact there were serious errors arising from both these causes.

It was here that Mr. Lyman took up the matter. He avoided Schumann's difficulty arising from the use of a prism spectroscope by employing a Rowland concave diffraction grating, which serves at once as a mirror wherewith to focus the rays upon the sensitive plate and a grating to disperse them and which, moreover, allows exact measurement of the wave-length of the photographed lines, while, of course, no prisms or lenses being used the difficulty arising from their absorption does not exist. The grating had 15,028 lines to the inch. He found that a grating was physically suitable for use with these high radiations, and he devised an ingenious two-slit method for determining accurately the wave lengths of all such lines as should be photographed. He also made use of a curved photographic plate for better definition.

As was the case in Schumann's research the whole apparatus was placed in a vacuum chamber. This was filled with hydrogen gas scrupulously purified and rarefied to a density of about 1/500 of an atmosphere.

To avoid difficulty from the absorption of the radiations from the electric spark which would be exercised even by a fluorite window in the vacuum tube in which the electrical spark was produced this opened directly into the chamber containing the spectroscope so that the radiations passed only through rarefied hydrogen before and after they fell upon the grating and reached the camera. By this device Professor Lyman was able to photograph and measure rays whose wave length was only 905 Å. and later those of wave length 600 Å. He showed that most serious absorption occurred with Schumann's optical train, so that no rays shorter than 1,267 Å were transmitted, which was therefore Schumann's limit. He mapped with great care the rays from the spark in a hydrogen vacuum tube, recording many hundred lines. He also studied the radiations in the Schumann region produced by the electric spark taken between electrodes of other substances, such as aluminium and the alkaline earths, and likewise the absorption of certain solids used for optical purposes and of various gases. It was with one of the latter, helium, that the extreme short wave length, 600 Å, was reached. In the progress of the investigations various new lines were measured which were of importance as verifying theoretical prediction regarding spectral series. Of course, in all these last researches the spark had to be taken within a vacuum tube with a fluorite window, so that no radiations above Schumann's limit or thereabouts could be reached.

There is a great region beyond these ultra-violet radiations studied by Schumann and Lyman, doubtless occupied by rays which have not yet been detected although searched for, but far above this limit are found the X-rays, long believed to be ether waves, and more recently proved to be such by the actual measure of their length by the Braggs, father and son. Their wave length is 1 Å, more or less, according to conditions. This is the extreme limit of measured ether waves, but the so-called "Gamma rays," emitted by radioactive substances, have a wave length estimated at perhaps 1/10 Å.

The President presented the medals to Professor Lyman, who expressed his thanks, and then addressed the Academy on "Flash and Sound Ranging with the American Forces in France."

The meeting then adjourned.

One thousand and eighty-second Meeting.

MAY 14, 1919.— ANNUAL MEETING.

The Academy met at its House.

The PRESIDENT in the Chair.

There were thirty-six Fellows and one guest present.

The Chair announced the death of Joseph Barrell, Fellow in Class II., Section 1.

The following report of the Council was presented:—

Since the last report of the Council, there have been reported the deaths of eighteen Fellows: G. K. Gilbert, F. R. Hutton, C. C. Smith, G. M. Searle, Arlo Bates, W. L. Hooper, J. J. Putnam, S. W. Williston, C. R. Van Hise, F. P. Mall, A. D. White, Timothy Dwight, W. H. Page, W. C. Sabine, C. J. Blake, E. C. Pickering, J. W. Baird, Joseph Barrell; and of five Foreign Honorary Members: J. A. H. Murray, Adolf von Baeyer, Hermann zu Solms-Laubach, Angelo Celli, Emil von Behring.

Twenty Fellows were elected by the Academy in May, 1918, of which number, one has declined Fellowship. One Fellow has resigned. Under the new provisions of the Statutes, the Council elected in April, 1919, twenty-five Fellows and nine Foreign Honorary Members.

The roll now includes 540 Fellows and 71 Foreign Honorary Members.

The annual report of the Treasurer was read, of which the following is an abstract:—

GENERAL FUND.

Receipts.

Balance, April 1, 1918	$5,735.36	
Investments	5,875.72	
Assessments	2,945.00	
Admissions	100.00	
Sundries	180.55	$14,836.63

Expenditures.

Expense of Library	$2,848.55
Expense of House	1,895.95
Treasurer	445.48
Assistant Treasurer	250.00
General Expense of Society	666.44
President's Expenses	51.25

Interest on Bonds, bought	.80	
Income transferred to principal	317.82	$6,476.29
Balance, April 1, 1919		8,360.34
		$14,836.63

RUMFORD FUND.

Receipts.

Balance, April 1, 1918	$2,902.21	
Investments	3,655.46	
Sale of publications	22.73	
Grant returned	81.33	$6,661.73

Expenditures.

Research	$1,300.00	
Periodicals and binding	101.54	
Medals	1,031.17	
Sundries	4.25	
Interest on Mortgage, bought	5.50	
Income transferred to principal	155.04	$2,597.50
Balance, April 1, 1919		4,064.23
		$6,661.73

C. M. WARREN FUND.

Receipts.

Balance, April 1, 1918	$3,673.58	
Investments	1,158.14	$4,831.72

Expenditures.

Sundries	$3.00	
Income transferred to principal	52.59	$55.59
Balance, April 1, 1919		4,776.13
		$4,831.72

PUBLICATION FUND.

Receipts.

Balance, April 7, 1919	$2,815.49	
Appleton Fund investments	1,049.63	
Centennial Fund investments	2,584.21	
Author's Reprints	631.98	
Sale of Publications	270.44	$7,351.75

Expenditures.

Publications	$5,716.53	
Sundries	10.00	
Income transferred to principal	163.72	$5,890.25
Balance, April 1, 1919		1,461.50
		$7,351.75

FRANCIS AMORY FUND.

Receipts.

Investments	$1,222.50	$1,222.50

Expenditures.

Publishing statement	$63.40	
Interest on Bonds, bought	7.50	
Charge to cancel Premium on Bonds	45.00	
Income transferred to principal	1,106.60	$1,222.50

The following reports were also presented:—

REPORT OF THE LIBRARY COMMITTEE.

The Librarian begs to report for the year 1918–1919, as follows:—

During the year 93 books have been borrowed by 16 persons, including 12 Fellows and 2 libraries. A great many books have been consulted, though not taken from the library. All books taken out have been returned or satisfactorily accounted for.

The number of volumes on the shelves at the time of the last report was 35,700. 537 volumes have been added, making the number now on the shelves 36,237. This includes 19 purchased from the income of the General Fund, 10 from that of the Rumford Fund, and 508 received by gift or exchange. The pamphlets added during the year number 123.

The expenses charged to the Library during the financial year are:—

Salaries	$2,300.00
Binding:—	
General Fund	252.55
Rumford Fund	29.05
Purchase of periodicals and books:—	
General Fund	171.15
Rumford Fund	78.09
Miscellaneous	119.25
Total	$2,950.09

A. G. WEBSTER, *Librarian.*

May 14, 1919

REPORT OF THE RUMFORD COMMITTEE.

The Rumford Committee respectfully reports as follows:—

The Committee met on November 13, 1918, and elected Charles R. Cross, Chairman, and Arthur G. Webster, Secretary.

During the past year grants in aid of research have been made as ollows:—

November 13, 1918. To Professor R. C. Gibbs for the continuance of his investigation on the absorption of organic and silver solutions for ultra-violet and infra-red rays (additional)	$250
To Dr. Louis T. E. Thompson in aid of his research on the development of a gun sight with two magnifications, for application to anti-aircraft guns	$250
January 9, 1919. To Professor H. M. Randall, in aid of his research on the infra-red spectrum (additional)	$200

To Professor Alpheus W. Smith in aid of his investigations on the Hall effect and allied phenomena in rare metals and their alloys (additional) $100

To Professor Julius Stieglitz in aid of the publication of Marie's tables of constants (additional) $250

To Professor A. G. Webster in aid of his researches on phrodynamics and practical interior ballistics $500

May 14, 1919. To Professor P. W. Bridgman in aid of his research on the effect of temperature and pressure on the physical properties of materials, particularly their thermal conductivity (additional) $400

To Professor Horace L. Howes in aid of his research on the experimental study of the effect of temperature on the luminescence and selective radiation of the rare earths $500

May 14, 1919, it was voted: To publish, as a Memoir of the Academy by an appropriation from the income of the Rumford Fund not exceeding $1,000, the results of measurements of the light of faint stars made at several Observatories possessing large telescopes by the use of the form of photometer devised for that purpose by Professor E. C. Pickering and constructed by means of a grant from the Rumford Committee.

Reports of progress in their respective researches have been received from the following persons:— C. G. Abbot, W. M. Baldwin, R. T. Birge, P. W. Bridgman, W. W. Campbell, A. L. Clark, H. Crew, F. Daniels, A. L. Foley, E. B. Frost, R. C. Gibbs, H. C. Hayes, H. P. Hollnagel, L. R. Ingersoll, N. A. Kent, F. E. Kester, L. V. King, C. A. Kraus, E. Kremers, C. E. Mendenhall, R. A. Millikan, R. S. Minor, E. L. Nichols (finished), C. L. Norton, F. Palmer, Jr., J. A. Parkhurst, H. M. Randall, T. W. Richards, F. K. Richtmyer, G. W. Ritchey, M. A. Rosanoff (finished), J. Stieglitz, A. St. John (research discontinued), F. A. Saunders, W. O. Sawtelle, A. W. Smith, B. J. Spence, L. T. E. Thompson, O. Tugman, F. W. Very, A. G. Webster, D. L. Webster, R. W. Wood.

No papers have been published by the Academy at the expense of the Rumford Fund during the present year.

The various reports from grantees received last year and the present year indicate that the exigencies of the war have made such demands on the time and abilities of scientific men of the country as practically to preclude their continuance of investigations to any considerable extent. The reports, however, indicate an intention and expectation of an early resumption of individual research.

The Committee desires to call attention to a marked improvement in the execution of the engraved portion of the recently-presented Rumford medals, which has been secured through the interest and energy of the Treasurer of the Academy. For a long time past this lettering has uniformly been done in plain square Roman type, which has abolished such occasional manifestations of the idiosyncrasies of individual engravers as had occurred previously. Though the work was entrusted to the best local skill available, nevertheless, the results were not always beyond criticism. The plain lettering used is probably harder to execute than script or ornamentation, and the difficulty is frequently enhanced by the length of the inscription necessary and often by the length of the individual words composing it as well. Realizing these facts, the Treasurer took up the matter with the authorities of the United States Mint at Philadelphia and secured the active interest of the chief engraver, who has taken charge of the engraving of the last two medals, employing the skill and improved methods thus available. As a result these are of a beauty far transcending that of any earlier ones. A marked improvement in the bronze replicas has also been made by a change in the character of the metal employed. The labors of Mr. Edes in this direction are warmly appreciated by the Committee.

It is impossible to close this report without a reference to the great loss recently sustained by the Committee directly, and indirectly by all those who may hereafter desire aid from the Rumford Fund, through the death of Professor Edward C. Pickering. The period through which his membership has extended is entirely unprecedented. From May, 1869, up to February last, his term of service was continuous except for a brief gap, 1890–1892, during which time he was awarded the Rumford Premium. Very rarely did he miss a meeting and never did he fail to give full attention to any matter which was before the Committee. His temperate judgment, totally unaffected by any other than scientific considerations, and his clearness of apprehension of the probable value of a proposed investigation, were of high importance. He was especially appreciative of the needs of younger men who were desirous of aid from the Fund, and fully recognized the hindrances to research which so often lie in their way in collegiate institutions. Particularly were all these characteristics to be depended upon when the award of the Rumford Premium was under consideration, in which case their value was inestimable. His judgment was exacting as to the merit of the candidate, but always kindly and considerate, his sole desire being to recognize important scientific results and through such recognition to stimulate the further labors of the recipient and of others working in similar fields.

His refinement of manner and thought and his cordial appreciation of all with whom he was associated made the sessions of the Committee delightful in their social aspect and will long be a cherished remembrance with his colleagues.

Charles R. Cross, *Chairman.*

May 14, 1919.

Report of the C. M. Warren Committee.

The C. M. Warren Committee begs to submit the following report:—

At the date of the last report to the Academy, the Committee had at its disposal $2,771.50. In March, 1919, the Academy made a further appropriation of $800.

One grant has been made during the year, namely, that to Professor Robert E. Wilson of $750 for the study of the hydrolysis of certain organic compounds, with particular reference to an exact study of phenomena which may be expected to throw desirable light upon the nature of the interface between two liquids. This investigation is a continuation of work done during the war in perfecting methods for the destruction of the so-called "mustard gas." This material, chemically known as di-chlorethylene sulphide, exhibited some highly interesting phenomena which, under the stress of war conditions, could not be followed up. The research promises to yield results of permanent interest.

The unexpended balance now in the hands of the Committee is $2,821.50.

No reports of publication of work carried on with the aid of grants from the C. M. Warren Fund have been received during the year, doubtless because so many of the investigators holding these grants have been engaged in war work.

Respectfully submitted,

H. P. Talbot, *Chairman.*

May 14, 1919.

Report of the Publication Committee.

The Committee of Publication submits the following report for the period from April 1, 1918, to April 1, 1919:—

During this period 846 pages of the Proceedings have been issued namely, Nos. 6–10, of Vol. 53, and Nos. 1–4 of Vol. 54; also 112 pages of the Memoirs, namely, No. 2 of Vol. 14.

Toward the expense of one of these numbers (Proceedings 53:7) Mr. Andrew McF. Davis contributed the sum of $100, and toward the expense of another (Proceedings 54:1) the Shaler Memorial Fund of Harvard University contributed $387.29. Both of these sums are included in the item of "extra" reprints.

The accounts of the Committee of Publication stand as follows:

Balance on hand April 1, 1918	$2,485.88
Appropriation for 1918–19	3,500.00
Proceeds from the sale of publications	270.44
Total available funds	6,256.32
Expenses	5,084.55
Balance on hand April 1, 1919	1,171.77

During the year authors have ordered through the Committee "extra" reprints to the amount of $631.98; to this sum should be added $1,146.00 for "extra" reprints of the article in the Memoirs, the bill for which was, by error, sent directly by the printer to the authors.

Professor Huntington, the Chairman of the Committee, has been at Washington since June, serving as Major in the United States Army, assigned to duty in the statistics branch of the General Staff.

Respectfully submitted,

Albert A. Howard, *Acting Chairman.*

May 14, 1919.

Report of the House Committee.

The House Committee submits the following report for 1918–19:—

With the balance of $20.30 left from last year, an appropriation of $2,000 and money received from other societies for the use of the rooms, the Committee has had at its disposal the sum of $2,040.30. The total expenditure has been $1,915.95, leaving an unexpended balance on April 1, 1919, of $124.35. The expenditure has been as follows:—

Janitor		$851.42
Electricity	A. Light	117.43
	B. Power	48.47
Gas		11.63
Water		8.00
Telephone		51.79
Coal	Furnace	593.66
	Water heater	44.10
Wood		23.30
Ash tickets		9.90
Care of elevator		34.41
Ice		18.00
Janitor's materials		28.88
Furnishings		29.45
Upkeep		43.01
Sundries		2.50
Total expenditure		$1,915.95

The amount of $20 contributed by other societies for the use of the building leaves the net expense of the House $1,895.95.

Meetings have been held as follows:—

The Academy	8
Harvard Biblical Club	7
The Colonial Society	4
American Antiquarian Society	1
Archæological Institute of America	1

The rooms on the first floor have been used many times for Committee meetings.

The Committee expended about $150 more than last year, which is accounted for in the advancing cost of everything. Had not the increased price of coal been in a great measure offset by the mildness of the winter, the difference in the coal bill ($637.76 for 1918–19, $602.30 for 1917–18) would have been considerably greater.

Not wishing to discharge the wife of the late janitor, the Committee has adopted the policy of retaining Mrs. Reardon and giving her the use of the janitor's rooms. A man to look after the furnace, etc., is hired only for the months during which the furnace is burning.

Respectfully submitted,

G. R. Agassiz, *Chairman.*

May 14, 1919.

It was

Voted, To amend the Statutes in accordance with the report of the Committee, as follows:—

Chapter IX., Article 1, paragraph 2, to read

"It shall consider all nominations duly sent to it by any Class Committee and act upon them in accordance with the provisions of Chapter III."

On motion of the Treasurer, it was

Voted, That the Annual Assessment be $10.00.

A biographical notice of S. W. Williston by H. W. Shimer was presented.

The question of printing communications from non-members was referred to the Publication Committee.

The annual election resulted in the choice of the following officers and committees:—

Theodore W. Richards, *President.*
Elihu Thomson, *Vice-President for Class I.*
Harvey Cushing, *Vice-President for Class II.*
George F. Moore, *Vice-President for Class III.*
Harry W. Tyler, *Corresponding Secretary.*
James H. Ropes, *Recording Secretary.*
Henry H. Edes, *Treasurer.*
Arthur G. Webster, *Librarian.*

Councillors for Four Years.

Cecil H. Peabody, *of Class I.*
Edward M. East, *of Class II.*
Charles B. Gulick, *of Class III.*

Finance Committee.

Henry P. Walcott,
John Trowbridge,
Harold Murdock.

Rumford Committee.

Charles R. Cross,
Arthur G. Webster,
Arthur A. Noyes,
Elihu Thomson,
Theodore Lyman,
Louis Bell,
Percy W. Bridgman.

C. M. Warren Committee.

Henry P. Talbot,
Charles L. Jackson,
Gregory P. Baxter,
Arthur A. Noyes,
Walter L. Jennings,
William H. Walker,
Arthur D. Little.

Publication Committee.

Edward V. Huntington, *of Class I.*
Jay B. Woodworth, *of Class II.*
Albert A. Howard, *of Class III.*

Library Committee.

Harry M. Goodwin, *of Class I.*
Thomas Barbour, *of Class II.*
William C. Lane, *of Class III.*

House Committee.

Louis Derr,
George R. Agassiz,
Wm. Sturgis Bigelow.

Committee on Meetings.

THE PRESIDENT, WILLIAM M. DAVIS,
THE RECORDING SECRETARY, EDWIN B. WILSON,
GEORGE F. MOORE.

Auditing Committee.

GEORGE R. AGASSIZ, JOHN E. THAYER.

The Council reported that the following gentlemen were elected members of the Academy:—

Joseph Lipka, of Cambridge, as Fellow in Class I., Section 1. (Mathematics and Astronomy.)

George Abram Miller, of Urbana, as Fellow in Class I., Section 1. (Mathematics and Astronomy.)

Forest Ray Moulton, of Chicago, as Fellow in Class I., Section 1. (Mathematics and Astronomy.)

Virgil Snyder, of Ithaca, as Fellow in Class I., Section 1. (Mathematics and Astronomy.)

William Suddards Franklin, of Cambridge, as Fellow in Class I., Section 2. (Physics.)

Arthur Alphonzo Blanchard, of Cambridge, as Fellow in Class I., Section 3. (Chemistry.)

Frederick George Keyes, of Cambridge, as Fellow in Class I., Section 3. (Chemistry.)

Edward Mueller, of Cambridge, as Fellow in Class I., Section 3. (Chemistry.)

Ellwood Barker Spear, of Cambridge, as Fellow in Class I., Section 3. (Chemistry.)

Robert Seaton Williams, of Cambridge, as Fellow in Class I., Section 3. (Chemistry.)

Alpheus Grant Woodman, of Watertown, as Fellow in Class I., Section 3. (Chemistry.)

Henri Louis Le Chatelier, of Paris, as Foreign Honorary Member in Class I., Section 3. (Chemistry.)

William Henry Perkin, of Oxford, as Foreign Honorary Member in Class I., Section 3. (Chemistry.)

Frederic Harold Fay, of Boston, as Fellow in Class I., Section 4. (Technology and Engineering.)

Ferdinand Foch, of Paris, as Foreign Honorary Member in Class I., Section 4. (Technology and Engineering.)

Joseph Jacques Césaire Joffre, of Paris, as Foreign Honorary Member in Class I., Section 4. (Technology and Engineering.)

Waldemar Theodore Schaller, of Washington, as Fellow in Class II., Section 1. (Geology, Mineralogy and Physics of the Globe.)

Charles Barrois, of Lille, as Foreign Honorary Member in Class II., Section 1. (Geology, Mineralogy and Physics of the Globe.)

Raymond Pearl, of Washington, as Fellow in Class II., Section III. (Zoölogy and Physiology.)

George H. F. Nuttall, of Cambridge, as Foreign Honorary Member in Class II., Section 3. (Zoölogy and Physiology.)

Alexis Carrel, of New York, as Fellow in Class II., Section 4. (Medicine and Surgery.)

Charles Henry Brent, of Manila, as Fellow in Class III., Section 1. (Theology, Philosophy and Jurisprudence.)

Howard Nicholson Brown, of Boston, as Fellow in Class III., Section 1. (Theology, Philosophy and Jurisprudence.)

John Bassett Moore, of New York, as Fellow in Class III., Section 1. (Theology, Philosophy and Jurisprudence.)

Winslow Warren, of Dedham, as Fellow in Class III., Section 1. (Theology, Philosophy and Jurisprudence.)

Raymond Poincaré, of Paris, as Foreign Honorary Member in Class III., Section 1. (Theology, Philosophy and Jurisprudence.)

Pliny Earle Goddard, of New York, as Fellow in Class III., Section 2. (Philology and Archæology.)

Roy Kenneth Hack, of Cambridge, as Fellow in Class III., Section 2. (Philology and Archæology.)

William Henry Holmes, of Washington, as Fellow in Class III., Section 2. (Philology and Archæology.)

Arthur Anthony Macdonell, of Oxford, as Foreign Honorary Member in Class III., Section 2. (Philology and Archæology.)

Charles Downer Hazen, of New York, as Fellow in Class III., Section 3. (Political Economy and History.)

Charles Lemuel Nichols, of Worcester, as Fellow in Class III., Section 3. (Political Economy and History.)

George Walter Prothero, of London, as Foreign Honorary Member in Class III., Section 3. (Political Economy and History.)

Henry Dwight Sedgwick, of New York, as Fellow in Class III., Section 4. (Literature and the Fine Arts.)

The following Communication was presented: —

Professor A. M. Tozzer, "The Sacred Cenote of Chichen Itza, Yucatan, and its contents."

The following papers were presented by title:

"A Revision of the North American Species of Rana," by George Albert Boulenger (of England), presented by Samuel Henshaw and Thomas Barbour.

"A Step Forward in the Methodology of Natural Science (an introduction to the functional relation of one variable to each of a number of correlated variables, determined by a method of successive approximation to group averages, by George F. McEwen and Ellis L. Michael)," by Wm. E. Ritter.

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WILLIAM BULLOCK CLARK (1860–1917)

Fellow in Class II, Section 1, 1916

As my old pupil and assistant John Mason Clarke has prepared a full memorial for the National Academy and a fine appreciation for the Bulletin of the Geological Society of this my other pupil and good friend, who is now gone, I may set down here more of personal reminiscence of our early work together and many later meetings.

I remember visiting him at his fine home in the beautiful city of Brattleboro where he was an only child, and driving with him up to the large farm which overlooked the city, where he added country life to town life during his school days. I remember his father, a sturdy, respected and influential citizen, and his good mother whom he seemed strongly to resemble.

It was good old Massachusetts Bay stock on both sides, and his ancestor Thomas Clarke was in Plymouth in 1623. In those early days the tribes spread down the Massachusetts and Connecticut shores and up the Connecticut River, along "Puritan Street" as it was called, because the straight route west was dangerous and the meadows of the river did not require clearing.

And so his father came to live in Brattleboro, and Clark fitted for College in the high school of the town.

When he came to study geology he was clear-headed, persistent and enthusiastic.

He mapped, as many of my boys have done, the surface geology around the Golden Gate Pond in North Amherst, a name given by Edward Hitchcock, and the solid geology of a section of the Holyoke Range, and he did his work well.

Near the end of senior year he came to me and announced that he wished to take post-graduate work in geology at Amherst, and wished my advice on the desirability of the plan, in view of the fact that he was color blind. "How did you do your chemistry"? I asked.

If he had a colored precipitate, he said, he showed it to a neighbor with some remark as to its color which was generally corrected, and he noted the correction carefully and memorized the same carefully, and no one knew of the defective vision. I then told him he would have to avoid mineralogy and center in paleontology.

A few weeks before Commencement, I called him and told him that

I was to start for a summer trip to Europe with Prof. Wm. North Rice, and that if he wanted to study geology I could never give him a better chance, if he would come with us.

He went home next Sunday and it was a bomb shell in this quiet methodical family, but he joined us on the trip. I think it had been settled that he should continue abroad for study, for he met me in New York with a large Saratoga trunk and a smaller trunk and I persuaded him to cull out what he really needed and send most of the material home in the bigger trunk.

With my careless and forgetful ways I am afraid I was a trial for him with his methodical and careful habit of doing things, for his interesting letters were sent by his mother down to my home for the amusement of my people, and he often reported how I would plan out everything at night and start in an entirely different direction the next morning.

It was all taken with pleasant equanimity by Clark, and I only learned of it all afterward from the report of his letters.

He carried the "big Dana" as we called it then, Dana's Manual, and studied it faithfully all the way. He took the fullest notes and collected abundantly, and as we studied from Staffa through Scotland, York, Durham, Lyme Regis, Cornwall and down to the Lizard; and as thoroughly through Germany and Switzerland; he had good opportunity for very varied geological work.

At the end I advised him to study with Zittel in Munich as the best place for paleontological and stratigraphical work, and he made a fine thesis on taking his degree.

Now Remson and I had worked together in Göttingen; Professors Harmon Morse and George Huntington Williams were old pupils of mine and so I was naturally interested in Science in the Johns Hopkins, and when Williams needed an assistant I urged Clark for the place, especially, I suggested, because he would never encroach on Williams Optical Lithology work.

And so he started on his remarkable career in Maryland.

He married into another old New England family. His wife was Ellen Clark Strong, daughter of Edward A. Strong of Boston, and through her mother descended from the Clarks of Dorchester and Northampton, and so his four children Edward, Helen (Mrs. H. Findlay French) Atherton and Marion are of the purest strain of puritan descent. His wife by her fine artistic ability was of much help to him, especially in coloring his maps.

It is the more remarkable that this true New England Yankee should have so completely captured the southern State of Maryland.

He first organized the Maryland Weather Service and was made its director.

Then he created the Maryland Geological Survey. This was the work he loved best, and he published ten fine volumes of its results. He had Brögger of Christiania on for a course of lectures at the University, and as I had known Brögger in Norway he invited me down to meet him with a few others, and just naturally commandeered the Governor's steam yacht for an excursion of several days down Chesapeake Bay to study the Tertiary beds. Just as naturally he marched his party in the middle of the morning up from the boat to call on the Governor at the State House, Brögger trying to get the superabundant Maryland mud off his boots with the peen of his hammer. We were taken across to the gubernatorial mansion and treated to the finest hospitality of the South, and Brögger went back to the boat muttering "Mein Gott! Schnapps vor dem Mittagsessen"!

He then organized the Maryland States Roads Commission, one of the pioneers in that valuable work, and later was made executive officer of the State Board of Forestry. He was also Commissioner for the State of the Resurvey of Mason and Dixon's line.

He did as much for his City as for the State.

He was on the Committee to rebuild Baltimore after the great fire; on the Commission on City improvements, and on the Commission to widen the streets and create a civic center for the town. He was also president of the Henry Watson Children's aid Society of Baltimore; member of the State Tuberculosis Association, and vice-president of the Federated Charities of the City.

He belonged to the American, English, and German Geological Societies.

He was a member of the National Academy of Science and Chairman of its Geological section.

He was an L.L.D. of Amherst College, and so efficient in the administrative relations of the Johns Hopkins University that he was prominently suggested for the presidency of both institutions. He was a member of the Maryland Defence Council, and as a member of the National Research Council organized a Committee of about 50 geologists and highway engineers to report with maps on materials for rapid highway construction of our whole Atlantic and Gulf Coasts for a hundred miles back from the seaboard.

I undertook the work for Massachusetts and met him in June, of 1917, on a characteristic telegraphic summons, in Springfield for consultation on the matter, and found him the same genial, cordial, energetic man, grown portly with the years, but full strength and vigor.

He was on his way to "Stonecrop" his summer home at North Haven, Me., and it was a sad surprise to hear of his sudden death from apoplexy on July 27, 1917. If it had to be, it was a fortunate ending of a full life.

B. K. EMERSON.

FRANCIS HUMPHREYS STORER (1832-1914)

Fellow in Class I, Section 3, 1857

Francis Humphreys Storer, born in March, 1832, was a son of David Humphreys Storer, M. D. Harvard, 1825, from whom he inherited an ardent disposition, keen powers of observation, and an absolute sincerity in truth-seeking and truth-stating. His father belonged to a remarkable group of pioneering Massachusetts naturalists who were almost contemporaries in the second quarter of the nineteenth century. David Humphreys Storer published a "History of the Fishes of Massachusetts" in 1853-1867; George B. Emerson, Harvard A. B. 1817, published "Trees and Shrubs of Massachusetts" in 1846, a book which is still a classic; Thaddeus William Harris, Harvard A. B. 1815, published "Insects Injurious to Vegetation" in 1841, a pioneer entomological treatise of high merit; Augustus A. Gould, Harvard A. B. 1825, published in 1852 an important volume on the Molusca and Shells collected by the United States Exploring Expedition; Charles Pickering, Harvard A. B. 1823, published in 1848 "The Races of Man and their Geographical Distribution" (Vol. IX of the publications of the U. S. Exploring Expedition).

Francis Humphreys Storer grew up in this atmosphere of scientific research and publication, and was familiar with the scientific work of his father and of his father's contemporaries. Because of his own strong tendency to scientific studies his education did not follow the route ordinarily prescribed for the sons of successful professional men in Boston. He did not go to Harvard College, but to the new Lawrence Scientific School, where he spent the year 1850-51. For the next two years, he was by choice assistant to Professor Josiah P. Cooke of Harvard College, and then at the age of twenty-one he accepted an appointment as chemist to the United States North Pacific Exploring Expedition, and spent a year at sea and in numerous Pacific ports. At Commencement, 1855, he received on examination the Harvard degree of Bachelor of Science, and immediately went to Europe to pursue the study of chemistry in German laboratories.

On his return from Europe, in 1857, he forthwith opened a laboratory in Boston as an analytical and consulting chemist for all manufacturing, pharmaceutical and commercial purposes; and this laboratory he maintained with great industry and success for eight years.

When Professor William B. Rogers, the founder of the Massachusetts Institute of Technology, was organizing the first Faculty of that School in the spring of 1865, just at the end of the Civil War, his choice for Professor of General and Industrial Chemistry fell upon Francis Humphreys Storer, then thirty-three years of age. President Rogers's plans for creating a strong School of Technology in Boston commended themselves very much to Storer's judgment; and he was also eager to attempt to teach chemistry by the laboratory method, a method strongly favored by Professor Rogers in all the sciences. At the same time his friend and fellow-student under Professor Cooke, Charles W. Eliot, was appointed Professor of Analytical Chemistry in the Institute. In the fall of 1865 these two young professors began work on the Institute's first classes in some hired rooms on Summer Street, but were soon called on to plan and equip the chemical laboratories in the Institute's new building on Boylston Street. These laboratories were planned for teaching chemistry to all students, young or old, beginners or adepts, by the laboratory method. In these convenient and spacious laboratories Professors Storer and Eliot were soon experimenting not only on the students of the Institute but also on classes of teachers, both men and women, employed in schools in and about Boston. They soon found that a laboratory manual was needed for the use of their inexperienced students; and they accordingly wrote together a "Manual of Inorganic Chemistry" which was the first of its kind to be published in the English language, or indeed in any language. In order to make this book as good as possible for its novel uses, the authors used it in proof sheets for a year in their own teaching, with both their younger and their older students, and by this method effected within the year many slight and some substantial improvements in the text. This book attained a large circulation, and was kept alive for nearly fifty years by rather frequent revisions, at first by its authors, and later by younger men acting in association with Professor Storer. The two comrades also issued a "Manual of Qualitative Analysis" intended to promote the same method of laboratory teaching.

In 1869, Charles W. Eliot became President of Harvard University, and one of the first subjects to which he gave attention was the immediate establishment of the Bussey Institution, for which large funds had been accumulating for several years in possession of the University. These funds were invested chiefly in mercantile buildings in the heart of Boston, the income from which was satisfactory, and looked secure. The fine estate of over two hundred acres in West Roxbury, which Mr. Benjamin Bussey had left to the University, was in good order and ready for the service of the Bussey Institution as Mr. Bussey contemplated it. Accordingly, in 1870, a building was planned and put up containing the laboratories, lecture-rooms, library and offices of the Institution, and the work of creating a small Faculty for the Institution was begun. The professorship of Agricultural Chemistry was offered to Professor Storer, and was accepted by him in 1870. A year later he was made Dean of the Bussey Institution, an office which he held, with his professorship, till his retirement in 1907. Here the main work of Professor Storer's life was done. It began under the most favorable conditions, with adequate laboratories, including glass-houses, good experimental fields, and a sufficient income to cover not only teaching, but research. In June, 1871, he married Catharine Atkins Eliot, a sister of President Eliot, and the married pair occupied a house near the main building of the Institution.

In November, 1872, the great Boston fire occurred; and in that conflagration several of the best buildings in which the Bussey Fund was invested were destroyed, and the insurance on them was lost in part through the failure of the insuring companies. A large subscription was raised by the alumni and friends of Harvard University to make good its losses in this fire; but the Corporation of that day thought it best to use the whole of that fund to make good other losses which the University had suffered, and to give the Bussey Institution no advantage from it. Hence the cash income of the Institution was seriously and permanently reduced; and in consequence Professor Storer's department and the general activities of the Institution of which he was Dean were seriously crippled. This loss altered the subsequent tenor of Professor Storer's life. He continued to teach and study with enthusiasm; but his pupils were few in number, and his research work was painfully restricted. Nevertheless, he produced under these untoward circumstances his principal book, two volumes on "Agriculture in Some of its Relations with Chemistry," constructed out of his lectures during twenty-five years, and first published in 1897. This is a treatise of large permanent value, although agricultural science has developed rapidly during the twenty years since the book appeared. The scientific farmer of to-day may find in it innumerable facts and much reasoning of great value to him. The two volumes are affectionately inscribed to his father, of whom the son says, "To whose zealous example and constant encouragement are to be attributed whatever of scientific purpose may be found in them." In the last paragraph of the preface the author urges upon his reader, as he had been accustomed to urge upon his pupils, the great importance of studying two books by Professor Samuel William Johnson of Yale University, entitled "How Crops Grow" and "How Crops Feed," and remarks "Not a few points have here (that is, in Professor Storer's book) been lightly touched upon or even wholly omitted, simply because full explanations concerning them may be found in one or another of Johnson's books." Such remarks are distinctly unusual in the preface of one author about the publications of another on a similar subject. In this case the two authors were very unlike persons in temperament and habit of mind; but they were one in scientific spirit and desire to be serviceable.

During his long career as a chemist Professor Storer wrote numerous scientific communications for learned societies and contributions to the "Bulletin of the Bussey Institution." He also published two works which were the product of great industry and exactness in compiling all the accessible information on the subjects dealt with. The first of these publications appeared while he was a practicing commercial chemist in Boston under the title "Dictionary of the Solubilities of Chemical Substances." It was a work of great learning and great industry, which perfectly illustrates Storer's capacity for the patient labors of compiler and editor. A second publication of this sort appeared later in the "Cyclopaedia of Quantitative Chemical Analysis." Both these were works that could be carried on incidentally and without consecutive attention, in hours which other persons might have considered leisure hours. Professor Storer had no leisure. He relied for the preservation of his mental freshness and his bodily health on change of work, and a persistent habit of omnivorous reading.

After his wife died in 1882 he returned to Boston to live with unmarried sisters, to whom he was tenderly attached. An increasing deafness caused his withdrawal from most of his scientific fellowship and social intercourse during the last ten years of his life. He died 30 July, 1914, in the eighty-third year of his age.

CHARLES W. ELIOT.

Cambridge, 27 May, 1918.

FRANCIS BLAKE (1850–1913)

Fellow in Class I, Section 2, 1881

Francis Blake was the son of Francis and Caroline (Trumbull) Blake of Needham.

June 25, 1873, he married Miss Elizabeth L. Hubbard, daughter of Charles T. Hubbard of Weston, who survives him, together with one son and a married daughter.

Mr. Blake completed his school training on graduating from the Brookline High School in 1866. Shortly thereafter he entered upon scientific work for which he had a great predilection, in the United States Coast Survey, remaining in this service for thirteen years. During this time he took part in the remarkable work carried on by the Survey in the telegraphic determination of longitude in the course of which were determined the differences of longitude between the foreign observatories at Greenwich and Paris and the American observatories at Cambridge and Washington, when for the first time the transatlantic cable was employed to transmit the electric signal. The accuracy of this work was such as to astonish the world.

Mr. Blake was exceedingly inventive and was strongly impressed with the description which Professor Hughes published of his recently invented microphone in the spring of 1878. At that time the new but rapidly developing art of telephony called for a more powerful and more sensitive form of transmitter than was available, one which should be free from the various imperfections that were present in existing instruments. The original Hughes microphone, while exquisitely sensitive, was entirely unfitted for practical use. Mr. Blake after studying the problem with a most remarkable appreciation of the details of construction which would be necessary to ensure satisfactory results, devised the well-known Blake Transmitter. This was thereupon put into service by the Bell Telephone Co. in November, 1878. Among the novel devices in the working parts of the instrument, the use of platinum as the material of the hammer electrode and carbon for the anvil electrode, the one carried by a flexible spring, the other by a somewhat stiff spring, the complete separation of both electrodes from rigid connection with the diaphragm, the surrounding of the carbon anvil electrode with a mass of spun brass, all went to secure a delicacy of operation and precise reproduction of the spoken word free from scratching and breaking which no previous microphone transmitter had even remotely approached, and which few even in later times have rivalled. For its purpose, transmission over short distances up to perhaps fifty miles, the Blake transmitter was abundantly satisfactory. It continued to be the standard instrument in this country and was largely used abroad until with the extension of telephone lines to great distances a more powerful transmitter was called for, which need was finally supplied by the modern granulated carbon transmitter. In this country, in 1910, there were 270,000 Blake transmitters in use, the maximum number reached. Through this invention, Mr. Blake became known throughout the whole scientific and industrial world.

During subsequent years he devoted himself constantly to experimenting, and invented various other devices mostly, though not wholly electrical in their nature.

Besides his fellowship in this Academy, Mr. Blake was a member of many other societies, among which were the American Antiquarian Society, the Archæological Institute of America, the American Folk Lore Society, the American Forestry Association. He was Treasurer of this Academy for a number of years, and a Director of the American Bell Telephone Co. and its successor, the American Telegraph and Telephone Co., from 1879 until his death. He was also a member of the Corporation of the Massachusetts Institute of Technology, in whose Departments of Physics and Electrical Engineering he was greatly interested, and to which he devoted much helpful thought, as well as material aid. He represented the Institute as a Trustee of the Boston Museum of Fine Arts, and was likewise a Trustee of the Massachusetts General Hospital.

Mr. Blake was a man of the highest personal and professional worth, firm in his principles, decided in his opinions, sanguine and earnest in the prosecution of his plans, but always considerate of the views of others and affable in his association with men.

CHARLES R. CROSS.

SAMUEL WENDELL WILLISTON (1852–1918)

Fellow in Class II, Section 1, 1915

In the death of Doctor Williston, North America has lost one of its oldest and ablest workers in Vertebrate Paleontology. He had specialized in this branch of science since 1874, his especial field being extinct reptiles and amphibians. For the last decade and a half he was head of the Department of Vertebrate Paleontology in Chicago University.

Samuel Wendell Williston was born in Boston (Roxbury), Massachusetts, July 10, 1852; he died at Chicago, Illinois, August 30, 1918. His 66 years of life were strenuous ones, for with many handicaps and against many obstacles he won place for himself as one of the world's greatest authorities on Vertebrate Paleontology. His father, who traced his ancestry in Massachusetts back to 1650, could neither read nor write; he did not like study. His mother had a common school education. In the spring of 1857 the family emigrated to Manhattan, Kansas, at a time when the last 115 miles had to be made by ox-team. After attending the common schools of the town, he entered the State Agricultural College in 1866. Here his teacher of science, Professor B. F. Mudge, had great influence upon his future life. Though Professor Mudge taught all science from natural philosophy, through chemistry, geology, zoology, botany, veterinary science to surveying, conic sections and calculus, he found considerable time for research along geologic and paleontologic lines; and along these lines young Williston naturally became interested. After graduating from college in 1872 he followed Civil Engineering for a year, after which he studied medicine with his family physician. In 1874 he accepted the invitation of a friend to go with him to northwestern Kansas where Professor Mudge was collecting vertebrate fossils for Professor Marsh of Yale University. The following year he again joined the party and as a result of his successful work Marsh invited him to come to New Haven. Here while aiding Marsh in his paleontologic work he continued at intervals his study of medicine, receiving the degree of M.D. from Yale University in 1880 and Ph.D. from the same institution in 1885. On December 20, 1880, Doctor Williston married Miss Annie I. Hathaway of New Haven, Connecticut. Throughout this time, since 1876, he continued collecting vertebrate fossils for Professor Marsh in the western fields during the summer and acting as his assistant in paleontology during the winter. In 1885 he became Demonstrator of Anatomy at Yale and from 1886 to 1890 Professor of Anatomy. During this time he also practised medicine in New Haven. In 1890 he was called to the professorship of geology in the University of Kansas, where he taught invertebrate and vertebrate paleontology, anatomy and medicine, and was also dean of the Medical School. In 1902 he went to the University of Chicago as head of the newly established Department of Vertebrate Paleontology, remaining active here until his death.

Professor Williston was given no opportunity for research and publication by Professor Marsh; hence, with the exception of a brief paper on "American Jurassic Dinosaurs" published in the *Transactions of the Kansas Academy of Science* in 1878, his published researches in paleontology begin with 1890. While associated with the University of Kansas the majority of his papers appeared in the *Kansas University Quarterly*. During this time his work concerned itself mainly with turtles, plesiosaurs, mosasaurs and pterosaurs from the Permian and Mesozoic of Kansas. At the University of Chicago he could give most of his time to vertebrate paleontology, and here he gradually turned to the more difficult problems of the very early Amphibia and Reptilia. Most of the fossils upon which he worked came from the Texas Permian. This occupied the last decade of his life and in this he probably has made his greatest contribution to science. Two books stand out conspicuously in this last period, "American Permian Vertebrates" 1911, and "Water Reptiles of the Past and Present" 1914. In the latter, especially, Williston not only summarizes the previous knowledge and his latest researches, but gives the information to us in an intensely interesting way. In fact his work on "Water Reptiles" is as absorbingly interesting to read as it is scientifically satisfying in its array of facts. Only a writer thoroughly familiar with the structure and evolution of both past and present reptiles could bring before our eyes so vivid a picture of the swarming seas of the Cretaceous period of earth-history in what is now Kansas. This work is based upon his series of studies, previously published, of Kansas mosasaurs, plesiosaurs, crocodiles, etc., and is animated by the purpose to find out the why of every structure, to reconstruct from the bone fragments the appearance and habits of the living animals. Much of his work is illustrated by his own restorations of the reptiles and their habitats. At the time of his death he was actively engaged on a general work on the "Reptiles of the World, Recent and Fossil." This he began in 1917, and it is most unfortunate for both paleontologic and zoologic science that the many facts stored in his mind on this subject could not have found expression. Though Williston's work concerned itself principally with the ancient reptilian life of what is now central and southern United States, he also published researches upon sedimentary rocks, Mesozoic fish, Cenozoic mammals, including man, and especially upon the living Diptera. When associated with Professor Marsh, Williston despaired of publishing researches in paleontology, so he turned his actively observing mind upon the living flies. His interest in this subject continued to his death, though after 1899 he published in it only occasional papers. Between 1879 and 1899 his listed papers in Diptera total sixty-seven, amongst which is his "Manual of North American Diptera," a book still essential to workers along this line.

To all of us who have known Professor Williston the memory of him is helpful and inspiring. The writer has cause to remember especially his genial friendliness which expressed itself in most cordial generosity with original sketches and notes,— an aid which was extended at a time when Williston's thoughts were absorbed in anxious care of a much loved daughter. When a truly great man passes, his memory endures among his friends, not so much for the material and mental achievements he has accomplished, as for the spirit and inspiration of his service.

HERVEY WOODBURN SHIMER.

American Academy of Arts and Sciences

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(Corrected to August 7, 1919.)

FELLOWS.— 528.

(Number limited to six hundred.)

Class I.— *Mathematical and Physical Sciences.*— 186.

Section I.— *Mathematics and Astronomy.*— 42.

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Class I., Section II.— *Physics*.— 56.

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Harry Wheeler Morse	Los Angeles, Cal.
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Ernest Fox Nichols	New Haven, Conn.
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Elihu Thomson	Swampscott
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Charles August Kraus	Worcester
Arthur Becket Lamb	Cambridge
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Forris Jewett Moore	Boston
George Dunning Moore	Worcester
Edward Williams Morley	West Hartford, Conn.
Harmon Northrop Morse	Baltimore, Md.
Samuel Parsons Mulliken	Boston
Charles Edward Munroe	Forest Glen, Md.
James Flack Norris	Boston
Arthur Amos Noyes	Boston
William Albert Noyes	Urbana, Ill.
Thomas Burr Osborne	New Haven, Conn.
Samuel Cate Prescott	Brookline
Ira Remsen	Baltimore, Md.
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William Hultz Walker	Boston
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CLASS I., SECTION IV.— *Technology and Engineering.*— 42.

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Joseph Ruggles Worcester	Boston

Class II.— *Natural and Physiological Sciences.*— 162.

Section I.— *Geology, Mineralogy, and Physics of the Globe.*— 48.

Wallace Walter Atwood	Cambridge
George Hunt Barton	Cambridge
Isaiah Bowman	Washington, D. C.
Thomas Chrowder Chamberlin	Chicago, Ill.
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Henry Helm Clayton	Canton
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Frederic Brewster Loomis	Amherst

Alexander George McAdie	Readville
William John Miller	Northampton
Charles Palache	Cambridge
John Elliott Pillsbury	Washington, D. C.
Louis Valentine Pirsson	New Haven, Conn.
Raphael Pumpelly	Newport, R. I.
Percy Edward Raymond	Cambridge
William North Rice	Middletown, Conn.
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Waldemar Theodore Schaller	Washington, D. C.
Charles Schuchert	New Haven, Conn.
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Hervey Woodburn Shimer	Watertown
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Charles Doolittle Walcott	Washington, D. C.
Robert DeCourcy Ward	Cambridge
Charles Hyde Warren	Auburndale
Herbert Percy Whitlock	Albany, N. Y.
Bailey Willis	Palo Alto, Cal.
John Eliot Wolff	Cambridge
Jay Backus Woodworth	Cambridge
Frederick Eugene Wright	Washington, D. C.

Class II., Section II.— *Botany*.— 30.

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Irving Widmer Bailey	Cambridge
Liberty Hyde Bailey	Ithaca, N. Y.
Douglas Houghton Campbell	Palo Alto, Cal.
George Perkins Clinton	New Haven, Conn.
Frank Shipley Collins	North Eastham
John Merle Coulter	Chicago, Ill.
Bradley Moore Davis	Philadelphia, Pa.
Edward Murray East	Jamaica Plain
Alexander William Evans	New Haven, Conn.
Merritt Lyndon Fernald	Cambridge
George Lincoln Goodale	Cambridge
Robert Almer Harper	New York, N. Y.
John George Jack	East Walpole
Edward Charles Jeffrey	Cambridge
Fred Dayton Lambert	Tufts College

Burton Edward Livingston	Baltimore, Md.
George Richard Lyman	Washington, D. C.
Winthrop John Vanleuven Osterhout	Cambridge
Alfred Rehder	Jamaica Plain
Lincoln Ware Riddle	Wellesley
Benjamin Lincoln Robinson	Cambridge
Charles Sprague Sargent	Brookline
William Albert Setchell	Berkeley, Cal.
Arthur Bliss Seymour	Cambridge
Erwin Frink Smith	Washington, D. C.
John Donnell Smith	Baltimore, Md.
William Codman Sturgis	New York, N. Y.
Roland Thaxter	Cambridge
William Trelease	Urbana, Ill.

Class II., Section III.—*Zoölogy and Physiology.*—52.

Glover Morrill Allen	Boston
Joel Asaph Allen	New York, N. Y.
Thomas Barbour	Boston
Francis Gano Benedict	Boston
Henry Bryant Bigelow	Concord
Robert Payne Bigelow	Brookline
John Lewis Bremer	Boston
William Brewster	Cambridge
Charles Thomas Brues	Boston
Hermon Carey Bumpus	Tufts College
Walter Bradford Cannon	Cambridge
William Ernest Castle	Belmont
Charles Value Chapin	Providence, R. I.
Samuel Fessenden Clarke	Williamstown
Edwin Grant Conklin	Princeton, N. J.
William Thomas Councilman	Boston
Joseph Augustine Cushman	Sharon
William Healey Dall	Washington, D. C.
Charles Benedict Davenport	Cold Spring Harbor, N. Y.
Gilman Arthur Drew	Woods Hole
Alexander Forbes	Milton
Samuel Henshaw	Cambridge
Leland Ossian Howard	Washington, D. C.
Herbert Spencer Jennings	Baltimore, Md.

Charles Willison Johnson	Brookline
Charles Atwood Kofoid	Berkeley, Cal.
Frederic Thomas Lewis	Waban
Ralph Stayner Lillie	Worcester
Jacques Loeb	New York, N. Y.
Richard Swann Lull	New Haven, Conn.
Edward Laurens Mark	Cambridge
Ernest Gale Martin	Palo Alto, Cal.
Albert Davis Mead	Providence, R. I.
Edward Sylvester Morse	Salem
Herbert Vincent Neal	Tufts College
Henry Fairfield Osborn	New York, N. Y.
George Howard Parker	Cambridge
Raymond Pearl	Baltimore, Md.
John Charles Phillips	Wenham
Herbert Wilbur Rand	Cambridge
William Emerson Ritter	La Jolla, Cal.
William Thompson Sedgwick	Boston
Percy Goldthwait Stiles	Newtonville
John Eliot Thayer	Lancaster
Addison Emory Verrill	Whitneyville, Conn.
John Broadus Watson	Washington, D. C.
Arthur Wisswald Weysse	Boston
William Morton Wheeler	Boston
Harris Hawthorne Wilder	Northampton
Edmund Beecher Wilson	New York, N. Y.
Frederick Adams Woods	Brookline
Robert Mearns Yerkes	Washington, D. C.

Class II., Section IV.—*Medicine and Surgery.*—32.

Edward Hickling Bradford	Boston
Henry Asbury Christian	Boston
Harvey Cushing	Boston
David Linn Edsall	Boston
Harold Clarence Ernst	Jamaica Plain
Simon Flexner	New York, N. Y.
William Crawford Gorgas	Washington, D. C.
Robert Battey Greenough	Boston
William Stewart Halsted	Baltimore, Md.
Reid Hunt	Brookline

Henry Jackson	Boston
Elliott Proctor Joslin	Boston
William Williams Keen	Philadelphia, Pa.
Frank Burr Mallory	Brookline
Samuel Jason Mixter	Boston
Edward Hall Nichols	Boston
Sir William Osler, Bart.	Oxford, Eng.
Theophil Mitchell Prudden	New York, N. Y.
William Lambert Richardson	Boston
Milton Joseph Rosenau	Boston
Frederick Cheever Shattuck	Boston
Theobald Smith	Princeton, N. J.
Elmer Ernest Southard	Boston
Richard Pearson Strong	Boston
Ernest Edward Tyzzer	Boston
Frederick Herman Verhoeff	Boston
Henry Pickering Walcott	Cambridge
John Collins Warren	Boston
William Henry Welch	Baltimore, Md.
Francis Henry Williams	Boston
Simeon Burt Wolbach	Boston
Horatio Curtis Wood	Philadelphia, Pa.

Class III.— *Moral and Political Sciences.*— 180.

Section I.— *Theology, Philosophy and Jurisprudence.*— 50.

Thomas Willing Balch	Philadelphia, Pa.
Simeon Eben Baldwin	New Haven, Conn.
Willard Bartlett	Brooklyn, N. Y.
Joseph Henry Beale	Cambridge
Melville Madison Bigelow	Cambridge
Howard Nicholson Brown	Boston
Charles Warren Clifford	New Bedford
Edmund Burke Delabarre	Providence, R. I.
James De Normandie	Roxbury
Frederic Dodge	Belmont
Edward Staples Drown	Cambridge
William Harrison Dunbar	Cambridge
William Herbert Perry Faunce	Providence, R. I.
William Wallace Fenn	Cambridge

Frederick Perry Fish	Brookline
George Angier Gordon	Boston
John Wilkes Hammond	Cambridge
Alfred Hemenway	Boston
Charles Evans Hughes	New York, N. Y.
Frederick John Foakes Jackson	New York, N. Y.
William Lawrence	Boston
Arthur Lord	Plymouth
William Caleb Loring	Boston
Nathan Matthews	Boston
Samuel Walker McCall	Winchester
Edward Caldwell Moore	Cambridge
John Bassett Moore	New York, N. Y.
James Madison Morton	Fall River
George Herbert Palmer	Cambridge
Charles Edwards Park	Boston
Leighton Parks	New York, N. Y.
Endicott Peabody	Groton
Francis Greenwood Peabody	Cambridge
George Wharton Pepper	Philadelphia, Pa.
John Winthrop Platner	Cambridge
Roscoe Pound	Belmont
Elihu Root	New York, N. Y.
James Hardy Ropes	Cambridge
Arthur Prentice Rugg	Worcester
Henry Newton Sheldon	Boston
Moorfield Storey	Boston
William Howard Taft	New Haven, Conn.
William Jewett Tucker	Hanover, N. H.
William Cushing Wait	Medford
Williston Walker	New Haven, Conn.
Eugene Wambaugh	Cambridge
Edward Henry Warren	Boston
Winslow Warren	Dedham
Samuel Williston	Belmont
Woodrow Wilson	Washington, D. C.

Class III., Section II.— *Philology and Archæology.*— 51.

Francis Greenleaf Allinson	Providence, R. I.
William Rosenzweig Arnold	Cambridge
Maurice Bloomfield	Baltimore, Md.
Franz Boas	New York, N. Y.
Charles Pickering Bowditch	Jamaica Plain
Eugene Watson Burlingame	Albany, N. Y.
Edward Capps	Princeton, N. J.
Franklin Carter	Williamstown
George Henry Chase	Cambridge
Roland Burrage Dixon	Cambridge
William Curtis Farabee	Philadelphia, Pa.
Jesse Walter Fewkes	Washington, D. C.
Jeremiah Denis Mathias Ford	Cambridge
Basil Lanneau Gildersleeve	Baltimore, Md.
Pliny Earle Goddard	New York, N. Y.
Charles Hall Grandgent	Cambridge
Louis Herbert Gray	New York, N. Y.
Charles Burton Gulick	Cambridge
Roy Kenneth Hack	Cambridge
William Arthur Heidel	Middletown, Conn.
George Lincoln Hendrickson	New Haven, Conn.
Bert Hodge Hill	Athens, Greece
Elijah Clarence Hills	New York, N. Y.
Edward Washburn Hopkins	New Haven, Conn.
Joseph Clark Hoppin	Pomfret, Conn.
Albert Andrew Howard	Cambridge
William Guild Howard	Cambridge
Aleš Hrdlička	Washington, D. C.
Carl Newell Jackson	Cambridge
Hans Carl Gunther von Jagemann	Cambridge
James Richard Jewett	Cambridge
Alfred Louis Kroeber	Berkeley, Cal.
Kirsopp Lake	Cambridge
Henry Roseman Lang	New Haven, Conn.
Charles Rockwell Lanman	Cambridge
David Gordon Lyon	Cambridge
Clifford Herschel Moore	Cambridge
George Foot Moore	Cambridge
Hanns Oertel	New Haven, Conn.

Bernadotte Perrin	New Haven, Conn.
Edward Kennard Rand	Cambridge
George Andrew Reisner	Cambridge
Edward Robinson	New York, N. Y.
Fred Norris Robinson	Cambridge
Rudolph Schevill	Berkeley, Cal.
Edward Stevens Sheldon	Cambridge
Herbert Weir Smyth	Cambridge
Franklin Bache Stephenson	Claremont, Cal.
Charles Cutler Torrey	New Haven, Conn.
Alfred Marston Tozzer	Cambridge
James Haughton Woods	Cambridge

Class III., Section III.—*Political Economy and History.*—40.

Brooks Adams	Quincy
George Burton Adams	New Haven, Conn.
Charles McLean Andrews	New Haven, Conn.
Charles Jesse Bullock	Cambridge
Thomas Nixon Carver	Cambridge
John Bates Clark	New York, N. Y.
Archibald Cary Coolidge	Boston
Richard Henry Dana	Cambridge
Andrew McFarland Davis	Cambridge
Davis Rich Dewey	Cambridge
Ephraim Emerton	Cambridge
Henry Walcott Farnam	New Haven, Conn.
Irving Fisher	New Haven, Conn.
Worthington Chauncey Ford	Cambridge
Edwin Francis Gay	Cambridge
Frank Johnson Goodnow	Baltimore, Md.
Evarts Boutell Greene	Champaign, Ill.
Arthur Twining Hadley	New Haven, Conn.
Albert Bushnell Hart	Cambridge
Charles Homer Haskins	Cambridge
Isaac Minis Hays	Philadelphia, Pa.
Charles Downer Hazen	New York, N. Y.
Henry Cabot Lodge	Nahant
Abbott Lawrence Lowell	Cambridge
William MacDonald	New York, N. Y.
Roger Bigelow Merriman	Cambridge

Samuel Eliot Morison	Boston
William Bennett Munro	Cambridge
Charles Lemuel Nichols	Worcester
James Ford Rhodes	Boston
Henry Dwight Sedgwick	New York, N. Y.
William Milligan Sloane	New York, N. Y.
Henry Morse Stephens	Berkeley, Cal.
John Osborne Sumner	Boston
Frank William Taussig	Cambridge
William Roscoe Thayer	Cambridge
Frederick Jackson Turner	Cambridge
Thomas Franklin Waters	Ipswich
George Grafton Wilson	Cambridge
George Parker Winship	Cambridge

CLASS III., SECTION IV.— *Literature and the Fine Arts.*— 39.

George Pierce Baker	Cambridge
James Phinney Baxter	Portland, Me.
William Sturgis Bigelow	Boston
Le Baron Russell Briggs	Cambridge
Charles Allerton Coolidge	Boston
Ralph Adams Cram	Boston
Samuel McChord Crothers	Cambridge
Wilberforce Eames	New York, N. Y.
Henry Herbert Edes	Cambridge
Edward Waldo Emerson	Concord
Arthur Fairbanks	Cambridge
Arthur Foote	Brookline
Edward Waldo Forbes	Cambridge
Kuno Francke	Gilbertsville, N. Y.
Daniel Chester French	New York, N. Y.
Horace Howard Furness	Philadelphia, Pa.
Robert Grant	Boston
Morris Gray	Boston
Chester Noyes Greenough	Cambridge
Francis Barton Gummere	Haverford, Pa.
Henry Lee Higginson	Boston
James Kendall Hosmer	Minneapolis, Minn.
Mark Antony DeWolfe Howe	Boston
Archer Milton Huntington	New York, N. Y.

George Lyman Kittredge	Cambridge
William Coolidge Lane	Cambridge
Allan Marquand	Princeton, N. J.
Albert Matthews	Boston
Harold Murdock	Brookline
William Allan Neilson	Northampton
Thomas Nelson Page	Washington, D. C.
Herbert Putnam	Washington, D. C.
Denman Waldo Ross	Cambridge
John Singer Sargent	London, Eng.
Ellery Sedgwick	Boston
Richard Clipston Sturgis	Boston
Barrett Wendell	Boston
Owen Wister	Philadelphia, Pa.
George Edward Woodberry	Beverly

FOREIGN HONORARY MEMBERS.—65.

(Number limited to seventy-five.)

Class I.—*Mathematical and Physical Sciences.*—21.

Section I.—*Mathematics and Astronomy.*—6.

Johann Oskar Backlund	Petrograd
Felix Klein	Göttingen
Tullio Levi-Civita	Padua
Sir Joseph Norman Lockyer	London
Charles Emile Picard	Paris
Charles Jean de la Vallée Poussin	Louvain

Class I., Section II.—*Physics.*—8.

Svante August Arrhenius	Stockholm
Oliver Heaviside	Torquay
Sir Joseph Larmor	Cambridge
Hendrik Antoon Lorentz	Leyden
Max Planck	Berlin
Augusto Righi	Bologna
Sir Ernest Rutherford	Manchester
Sir Joseph John Thomson	Cambridge

Class I., Section III.—*Chemistry.*—3.

Fritz Haber	Berlin
Henri Louis Le Chatelier	Paris
Wilhelm Ostwald	Leipsic

Class I.—Section IV.—*Technology and Engineering.*—4.

Heinrich Müller Breslau	Berlin
Joseph Jacques Césaire Joffre	Paris
Vsevolod Jevgenjevic Timonoff	Petrograd
William Cawthorne Unwin	London

Class II.—*Natural and Physiological Sciences.*—20.

Section I.—*Geology, Mineralogy, and Physics of the Globe.*—8.

Frank Dawson Adams	Montreal
Waldemar Christofer Brögger	Christiania
Sir Archibald Geikie	Haslemere, Surrey
Viktor Goldschmidt	Heidelberg
Julius Hann	Vienna
Albert Heim	Zürich
Sir William Napier Shaw	London
Johan Herman Lie Vogt	Trondhjem

Class II., Section II.—*Botany.*—5.

John Briquet	Geneva
Adolf Engler	Berlin
Wilhelm Friedrich Philipp Pfeffer	Leipsic
Ignatz Urban	Berlin
Eugene Warming	Copenhagen

Class II.—Section III.—*Zoölogy and Physiology.*—3.

Sir Edwin Ray Lankester	London
George Henry Falkiner Nuttall	Cambridge
Magnus Gustav Retzius	Stockholm

Class II., Section IV.—*Medicine and Surgery.*—4.

Sir Thomas Barlow, Bart.	London
Adam Politzer	Vienna
Francis John Shepherd	Montreal
Charles Scott Sherrington	Oxford

Class III.— *Moral and Political Sciences.*— 24.

Section I.— *Theology, Philosophy and Jurisprudence.*— 5.

Rt. Hon. Arthur James Balfour	Prestonkirk
Heinrich Brunner	Berlin
Albert Venn Dicey	Oxford
Raymond Poincaré	Paris
Rt. Hon. Sir Frederick Pollock, Bart.	London

Section II.— *Philology and Archæology.*— 8.

Friedrich Delitzsch	Berlin
Hermann Diels	Berlin
Wilhelm Dörpfeld	Athens
Henry Jackson	Cambridge
Hermann Georg Jacobi	Bonn
Alfred Percival Maudslay	Hereford
Ramon Menendez Pidal	Madrid
Eduard Seler	Berlin

Section III.— *Political Economy and History.*— 6.

James Bryce, Viscount Bryce	London
Adolf Harnack	Berlin
Alfred Marshall	Cambridge
John Morley, Viscount Morley of Blackburn	London
George Walter Prothero	London
Rt. Hon. Sir George Otto Trevelyan, Bart.	London

Section IV.— *Literature and the Fine Arts.*— 5.

Georg Brandes	Copenhagen
Thomas Hardy	Dorchester
Jean Adrien Antoine Jules Jusserand	Paris
Rudyard Kipling	Burwash
Sir Sidney Lee	London

STATUTES AND STANDING VOTES

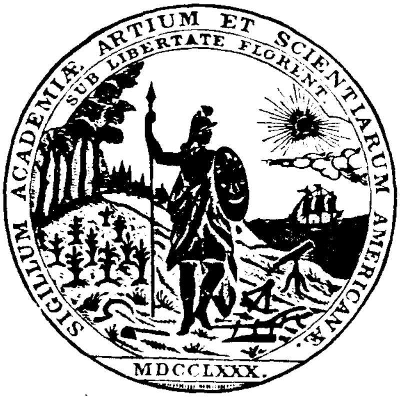
STATUTES

Adopted November 8, 1911: *amended May* 8, 1912, *January* 8, *and May* 14, 1913, *April* 14, 1915, *April* 12, 1916, *April* 10, 1918, *May* 14, 1919.

CHAPTER I

THE CORPORATE SEAL

ARTICLE 1. The Corporate Seal of the Academy shall be as here depicted:


SIGILLUM ACADEMIÆ ARTIUM ET SCIENTIARUM AMERICANÆ.
SUB LIBERTATE FLORENT
MDCCLXXX.

ARTICLE 2. The Recording Secretary shall have the custody of the Corporate Seal.

See Chap. v. art. 3; chap. vi. art. 2.

CHAPTER II

FELLOWS AND FOREIGN HONORARY MEMBERS AND DUES

ARTICLE 1. The Academy consists of Fellows, who are either citizens or residents of the United States of America, and Foreign Honorary Members. They are arranged in three Classes, according to the Arts and Sciences in which they are severally proficient, and each Class is divided into four Sections, namely:

CLASS I. *The Mathematical and Physical Sciences*
- Section 1. Mathematics and Astronomy
- Section 2. Physics
- Section 3. Chemistry
- Section 4. Technology and Engineering

CLASS II. *The Natural and Physiological Sciences*
- Section 1. Geology, Mineralogy, and Physics of the Globe
- Section 2. Botany
- Section 3. Zoölogy and Physiology
- Section 4. Medicine and Surgery

CLASS III. *The Moral and Political Sciences*
- Section 1. Theology, Philosophy, and Jurisprudence
- Section 2. Philology and Archaeology
- Section 3. Political Economy and History
- Section 4. Literature and the Fine Arts

ARTICLE 2. The number of Fellows shall not exceed Six hundred, of whom not more than Four hundred shall be residents of Massachusetts, nor shall there be more than Two hundred in any one Class.

ARTICLE 3. The number of Foreign Honorary Members shall not exceed Seventy-five. They shall be chosen from among citizens of foreign countries most eminent for their discoveries and attainments in any of the Classes above enumerated. There shall not be more than Twenty-five in any one Class.

ARTICLE 4. If any person, after being notified of his election as Fellow or Resident Associate, shall neglect for six months to accept in writing, or, if a Fellow or resident within fifty miles of Boston shall neglect to pay his Admission Fee, his election shall be void; and if any Fellow resident within fifty miles of Boston or any Resident Associate shall neglect to pay his Annual Dues for six months after they are due, provided his attention shall have been called to this

Article of the Statutes in the meantime, he shall cease to be a Fellow or Resident Associate respectively; but the Council may suspend the provisions of this Article for a reasonable time.

With the previous consent of the Council, the Treasurer may dispense (*sub silentio*) with the payment of the Admission Fee or of the Annual Dues or both whenever he shall deem it advisable. In the case of officers of the Army or Navy who are out of the Commonwealth on duty, payment of the Annual Dues may be waived during such absence if continued during the whole financial year and if notification of such expected absence be sent to the Treasurer. Upon similar notification to the Treasurer, similar exemption may be accorded to Fellows or Resident Associates subject to Annual Dues, who may temporarily remove their residence for at least two years to a place more than fifty miles from Boston.

If any person elected a Foreign Honorary Member shall neglect for six months after being notified of his election to accept in writing, his election shall be void.

See Chap. vii. art. 2.

ARTICLE 5. Every Fellow resident within fifty miles of Boston hereafter elected shall pay an Admission Fee of Ten dollars.

Every Fellow resident within fifty miles of Boston shall, and others may, pay such Annual Dues, not exceeding Fifteen dollars, as shall be voted by the Academy at each Annual Meeting, when they shall become due; but any Fellow or Resident Associate shall be exempt from the annual payment if, at any time after his admission, he shall pay into the treasury Two hundred dollars in addition to his previous payments.

All Commutations of the Annual Dues shall be and remain permanently funded, the interest only to be used for current expenses.

Any Fellow not previously subject to Annual Dues who takes up his residence within fifty miles of Boston, shall pay to the Treasurer within three months thereafter Annual Dues for the current year, failing which his Fellowship shall cease; but the Council may suspend the provisions of this Article for a reasonable time.

Only Fellows who pay Annual Dues or have commuted them may hold office in the Academy or serve on the Standing Committees or vote at meetings.

ARTICLE 6. Fellows who pay or have commuted the Annual Dues and Foreign Honorary Members shall be entitled to receive gratis one copy of all Publications of the Academy issued after their election.

See Chap. x, art. 2.

Article 7. Diplomas signed by the President and the Vice-President of the Class to which the member belongs, and countersigned by the Secretaries, shall be given to Foreign Honorary Members and to Fellows on request.

Article 8. If, in the opinion of a majority of the entire Council, any Fellow or Foreign Honorary Member or Resident Associate shall have rendered himself unworthy of a place in the Academy, the Council shall recommend to the Academy the termination of his membership; and if three fourths of the Fellows present, out of a total attendance of not less than fifty at a Stated Meeting, or at a Special Meeting called for the purpose, shall adopt this recommendation, his name shall be stricken from the Roll.

See Chap. iii.; chap. vi. art. 1; chap. ix. art. 1, 7; chap. x. art. 2.

CHAPTER III

Election of Fellows and Foreign Honorary Members

Article 1. Elections of Fellows and Foreign Honorary Members shall be made by the Council in April of each year, and announced at the Annual Meeting in May.

Article 2. Nominations to Fellowship or Foreign Honorary Membership in any Section must be signed by two Fellows of that Section or by three voting Fellows of any Sections; but in any one year no Fellow may nominate more than four persons. These nominations, with statements of qualifications and brief biographical data, shall be sent to the Corresponding Secretary.

All nominations thus received prior to February 15 shall be forthwith sent in printed form to every Fellow having the right to vote, with the names of the proposers in each case and a brief account of each nominee, and with the request that the list be returned before March 15, marked to indicate preferences of the voter in such manner as the Council may direct.

All the nominations, with any comments thereon and with the results of the preferential indications of the Fellows, received by March 15, shall be referred at once to the appropriate Class Committees, which shall report their decisions to the Council, which shall thereupon have power to elect.

Persons nominated in any year, but not elected, may be placed on the preferential ballot of the next year at the discretion of the Council, but shall not further be continued on the list of nominees unless renominated.

Notice shall be sent to every Fellow having the right to vote, not later than the fifteenth of January, of each year, calling attention to the fact that the limit of time for sending nominations to the Corresponding Secretary will expire on the fifteenth of February.

See Chap. ii.; chap. vi. art. 1; chap. ix. art. 1.

CHAPTER IV

OFFICERS

ARTICLE 1. The Officers of the Academy shall be a President (who shall be Chairman of the Council), three Vice-Presidents (one from each Class), a Corresponding Secretary (who shall be Secretary of the Council), a Recording Secretary, a Treasurer, and a Librarian, all of whom shall be elected by ballot at the Annual Meeting, and shall hold their respective offices for one year, and until others are duly chosen and installed.

There shall be also twelve Councillors, one from each Section of each Class. At each Annual Meeting three Councillors, one from each Class, shall be elected by ballot to serve for the full term of four years and until others are duly chosen and installed. The same Fellow shall not be eligible for two successive terms.

The Councillors, with the other officers previously named, and the Chairman of the House Committee, *ex officio*, shall constitute the Council.

See Chap. x. art. 1.

ARTICLE 2. If any officer be unable, through death, absence, or disability, to fulfill the duties of his office, or if he shall resign, his place may be filled by the Council in its discretion for any part or the whole of the unexpired term.

ARTICLE 3. At the Stated Meeting in March, the President shall appoint a Nominating Committee of three Fellows having the right to vote, one from each Class. This Committee shall prepare a list of nominees for the several offices to be filled, and for the Standing Committees, and file it with the Recording Secretary not later than four weeks before the Annual Meeting.

See Chap. vi. art. 2.

Article 4. Independent nominations for any office, if signed by at least twenty Fellows having the right to vote, and received by the Recording Secretary not less than ten days before the Annual Meeting, shall be inserted in the call therefor, and shall be mailed to all the Fellows having the right to vote.

See Chap. vi. art. 2.

Article 5. The Recording Secretary shall prepare for use in voting at the Annual Meeting a ballot containing the names of all persons duly nominated for office.

CHAPTER V

The President

Article 1. The President, or in his absence the senior Vice-President present (seniority to be determined by length of continuous fellowship in the Academy), shall preside at all meetings of the Academy. In the absence of all these officers, a Chairman of the meeting shall be chosen by ballot.

Article 2. Unless otherwise ordered, all Committees which are not elected by ballot shall be appointed by the presiding officer.

Article 3. Any deed or writing to which the Corporate Seal is to be affixed, except leases of real estate, shall be executed in the name of the Academy by the President or, in the event of his death, absence, or inability, by one of the Vice-Presidents, when thereto duly authorized.

See Chap. ii. art. 7; chap. iv. art. 1, 3; chap. vi. art. 2; chap. vii. art. 1; chap. ix. art. 6; chap. x. art. 1; 2; chap. xi. art. 1.

CHAPTER VI

The Secretaries

Article 1. The Corresponding Secretary shall conduct the correspondence of the Academy and of the Council, recording or making an entry of all letters written in its name, and preserving for the files all official papers which may be received. At each meeting of the Council he shall present the communications addressed to the Academy which have been received since the previous meeting, and at the next meeting of the Academy he shall present such as the Council may determine.

He shall notify all persons who may be elected Fellows or Foreign

Honorary Members, or Resident Associates, send to each a copy of the Statutes, and on their acceptance issue the proper Diploma. He shall also notify all meetings of the Council; and in case of the death, absence, or inability of the Recording Secretary he shall notify all meetings of the Academy.

Under the direction of the Council, he shall keep a List of the Fellows, Foreign Honorary Members, and Resident Associates, arranged in their several Classes and Sections. It shall be printed annually and issued as of the first day of July.

See Chap. ii. art. 7; chap. iii. art. 2, 3; chap. iv. art. 1; chap. ix. art. 6; chap. x. art. 1; chap. xi. art. 1.

ARTICLE 2. The Recording Secretary shall have the custody of the Charter, Corporate Seal, Archives, Statute-Book, Journals, and all literary papers belonging to the Academy.

Fellows or Resident Associates borrowing such papers or documents shall receipt for them to their custodian.

The Recording Secretary shall attend the meetings of the Academy and keep a faithful record of the proceedings with the names of the Fellows and Resident Associates present; and after each meeting is duly opened, he shall read the record of the preceding meeting.

He shall notify the meetings of the Academy to each Fellow and Resident Associate by mail at least seven days beforehand, and in his discretion may also cause the meetings to be advertised; he shall apprise Officers and Committees of their election or appointment, and inform the Treasurer of appropriations of money voted by the Academy.

After all elections, he shall insert in the Records the names of the Fellows by whom the successful nominees were proposed.

He shall send the Report of the Nominating Committee in print to every Fellow having the right to vote at least three weeks before the Annual Meeting.

See Chap. iv. art. 3.

In the absence of the President and of the Vice-Presidents he shall, if present, call the meeting to order, and preside until a Chairman is chosen.

See Chap. i.; chap. ii. art. 7; chap. iv. art. 3, 4, 5; chap. ix. art. 6; chap. x. art. 1, 2; chap. xi. art. 1, 3.

ARTICLE 3. The Secretaries, with the Chairman of the Committee of Publication, shall have authority to publish such of the records of the meetings of the Academy as may seem to them likely to promote its interests.

CHAPTER VII

THE TREASURER AND THE TREASURY

ARTICLE 1. The Treasurer shall collect all money due or payable to the Academy, and all gifts and bequests made to it. He shall pay all bills due by the Academy, when approved by the proper officers, except those of the Treasurer's office, which may be paid without such approval; in the name of the Academy he shall sign all leases of real estate; and, with the written consent of a member of the Committee on Finance, he shall make all transfers of stocks, bonds, and other securities belonging to the Academy, all of which shall be in his official custody.

He shall keep a faithful account of all receipts and expenditures, submit his accounts annually to the Auditing Committee, and render them at the expiration of his term of office, or whenever required to do so by the Academy or the Council.

He shall keep separate accounts of the income of the Rumford Fund, and of all other special Funds, and of the appropriation thereof, and render them annually.

His accounts shall always be open to the inspection of the Council.

ARTICLE 2. He shall report annually to the Council at its March meeting on the expected income of the various Funds and from all other sources during the ensuing financial year. He shall also report the names of all Fellows and Resident Associates who may be then delinquent in the payment of their Annual Dues.

ARTICLE 3. He shall give such security for the trust reposed in him as the Academy may require.

ARTICLE 4. With the approval of a majority of the Committee on Finance, he may appoint an Assistant Treasurer to perform his duties, for whose acts, as such assistant, he shall be responsible; or, with like approval and responsibility, he may employ any Trust Company doing business in Boston as his agent for the same purpose, the compensation of such Assistant Treasurer or agent to be fixed by the Committee on Finance and paid from the funds of the Academy.

ARTICLE 5. At the Annual Meeting he shall report in print all his official doings for the preceding year, stating the amount and condition of all the property of the Academy entrusted to him, and the character of the investments.

Article 6. The Financial Year of the Academy shall begin with the first day of April.

Article 7. No person or committee shall incur any debt or liability in the name of the Academy, unless in accordance with a previous vote and appropriation therefor by the Academy or the Council, or sell or otherwise dispose of any property of the Academy, except cash or invested funds, without the previous consent and approval of the Council.

See Chap. ii. art. 4, 5; chap. vi. art. 2; chap. ix. art. 6; chap. x. art. 1, 2, 3; chap. xi. art. 1.

CHAPTER VIII

The Librarian and the Library

Article 1. The Librarian shall have charge of the printed books, keep a correct catalogue thereof, and provide for their delivery from the Library.

At the Annual Meeting, as Chairman of the Committee on the Library, he shall make a Report on its condition.

Article 2. In conjunction with the Committee on the Library he shall have authority to expend such sums as may be appropriated by the Academy for the purchase of books, periodicals, etc., and for defraying other necessary expenses connected with the Library.

Article 3. All books procured from the income of the Rumford Fund or of other special Funds shall contain a book-plate expressing the fact.

Article 4. Books taken from the Library shall be receipted for to the Librarian or his assistant.

Article 5. Books shall be returned in good order, regard being had to necessary wear with good usage. If any book shall be lost or injured, the Fellow or Resident Associate to whom it stands charged shall replace it by a new volume or by a new set, if it belongs to a set, or pay the current price thereof to the Librarian, whereupon the remainder of the set, if any, shall be delivered to the Fellow or Resident Associate so paying, unless such remainder be valuable by reason of association.

ARTICLE 6. All books shall be returned to the Library for examination at least one week before the Annual Meeting.

ARTICLE 7. The Librarian shall have the custody of the Publications of the Academy. With the advice and consent of the President, he may effect exchanges with other associations.

See Chap. ii. art. 6; chap. x. art. 1, 2.

CHAPTER IX

THE COUNCIL

ARTICLE 1. The Council shall exercise a discreet supervision over all nominations and elections to membership, and in general supervise all the affairs of the Academy not explicitly reserved to the Academy as a whole or entrusted by it or by the Statutes to standing or special committees.

It shall consider all nominations duly sent to it by any Class Committee, and act upon them in accordance with the provisions of Chapter *III*.

With the consent of the Fellow interested, it shall have power to make transfers between the several Sections of the same Class, reporting its action to the Academy.

See Chap. iii. art. 2, 3; chap. x, art. 1.

ARTICLE 2. Seven members shall constitute a quorum.

ARTICLE 3. It shall establish rules and regulations for the transaction of its business, and provide all printed and engraved blanks and books of record.

ARTICLE 4. It shall act upon all resignations of officers, and all resignations and forfeitures of Fellowship or Resident Associateship; and cause the Statutes to be faithfully executed.

It shall appoint all agents and subordinates not otherwise provided for by the Statutes, prescribe their duties, and fix their compensation.

They shall hold their respective positions during the pleasure of the Council.

ARTICLE 5. It may appoint, for terms not exceeding one year, and prescribe the functions of, such committees of its number, or of the Fellows of the Academy, as it may deem expedient, to facilitate the administration of the affairs of the Academy or to promote its interests.

ARTICLE 6. At its March meeting it shall receive reports from the President, the Secretaries, the Treasurer, and the Standing Committees, on the appropriations severally needed for the ensuing financial year. At the same meeting the Treasurer shall report on the expected income of the various Funds and from all other sources during the same year.

A report from the Council shall be submitted to the Academy, for action, at the March meeting, recommending the appropriation which in the opinion of the Council should be made.

On the recommendation of the Council, special appropriations may be made at any Stated Meeting of the Academy, or at a Special Meeting called for the purpose.

See Chap. x. art. 3.

ARTICLE 7. After the death of a Fellow or Foreign Honorary Member, it shall appoint a member of the Academy to prepare a biographical notice for publication in the Proceedings.

ARTICLE 8. It shall report at every meeting of the Academy such business as it may deem advisable to present.

See Chap. ii. art. 4, 5, 8; chap. iv, art. 1, 2; chap. vi. art. 1; chap. vii, art. 1; chap. xi. art. 1, 4.

CHAPTER X

STANDING COMMITTEES

ARTICLE 1. The Class Committee of each Class shall consist of the Vice-President, who shall be chairman, and the four Councillors of the Class, together with such other officer or officers annually elected as may belong to the Class. It shall consider nominations to Fellowship in its own Class, and report in writing to the Council such as may receive at a Class Committee Meeting a majority of the votes cast, provided at least three shall have been in the affirmative.

See Chap. iii. art. 2.

ARTICLE 2. At the Annual Meeting the following Standing Committees shall be elected by ballot to serve for the ensuing year:

(i) *The Committee on Finance*, to consist of three Fellows, who, through the Treasurer, shall have full control and management of the funds and trusts of the Academy, with the power of investing the funds and of changing the investments thereof in their discretion.

See Chap. iv. art. 3; chap. vii. art. 1, 4; chap. ix. art. 6.

(ii) *The Rumford Committee*, to consist of seven Fellows, who shall report to the Academy on all applications and claims for the Rumford Premium. It alone shall authorize the purchase of books publications and apparatus at the charge of the income from the Rumford Fund, and generally shall see to the proper execution of the trust.

See Chap. iv. art. 3; chap. ix. art. 6.

(iii) *The Cyrus Moors Warren Committee*, to consist of seven Fellows, who shall consider all applications for appropriations from the income of the Cyrus Moors Warren Fund, and generally shall see to the proper execution of the trust.

See Chap. iv. art. 3; chap. ix. art. 6.

(iv) *The Committee of Publication*, to consist of three Fellows, one from each Class, to whom all communications submitted to the Academy for publication shall be referred, and to whom the printing of the Proceedings and the Memoirs shall be entrusted.

It shall fix the price at which the Publications shall be sold; but Fellows may be supplied at half price with volumes which may be needed to complete their sets, but which they are not entitled to receive gratis.

Two hundred extra copies of each paper accepted for publication in the Proceedings or the Memoirs shall be placed at the disposal of the author without charge.

See Chap. iv. art. 3; chap. vi. art. 1, 3; chap. ix. art. 6.

(v) *The Committee on the Library*, to consist of the Librarian, *ex officio*, as Chairman, and three other Fellows, one from each Class, who shall examine the Library and make an annual report on its condition and management.

See Chap. iv. art. 3; chap. viii. art. 1, 2; chap. ix. art. 6.

(vi) *The House Committee*, to consist of three Fellows, who shall have charge of all expenses connected with the House, including the general expenses of the Academy not specifically assigned to the care of other Committees or Officers.

See Chap. iv. art. 1, 3; chap. ix. art. 6.

(vii) *The Committee on Meetings*, to consist of the President, the Recording Secretary, and three other Fellows, who shall have charge of plans for meetings of the Academy.

See Chap. iv. art. 3; chap. ix. art. 6.

(viii) *The Auditing Committee*, to consist of two Fellows, who shall audit the accounts of the Treasurer, with power to employ an expert and to approve his bill.

See Chap. iv. art. 3; chap. vii. art. 1; chap. ix. art. 6.

ARTICLE 3. The Standing Committees shall report annually to the Council in March on the appropriations severally needed for the ensuing financial year; and all bills incurred on account of these Committees, within the limits of the several appropriations made by the Academy, shall be approved by their respective Chairmen.

In the absence of the Chairman of any Committee, bills may be approved by any member of the Committee whom he shall designate for the purpose.

See Chap. vii. art. 1, 7; chap. ix. art. 6.

CHAPTER XI

MEETINGS, COMMUNICATIONS, AND AMENDMENTS

ARTICLE 1. There shall be annually eight Stated Meetings of the Academy, namely, on the second Wednesday of October, November, December, January, February, March, April and May. Only at these meetings, or at adjournments thereof regularly notified, or at Special Meetings called for the purpose, shall appropriations of money be made or amendments of the Statutes or Standing Votes be effected.

The Stated Meeting in May shall be the Annual Meeting of the Corporation.

Special Meetings shall be called by either of the Secretaries at the request of the President, of a Vice-President, of the Council, or of ten

Fellows having the right to vote; and notifications thereof shall state the purpose for which the meeting is called.

A meeting for receiving and discussing literary or scientific communications may be held on the fourth Wednesday of each month, excepting July, August, and September; but no business shall be transacted at said meetings.

ARTICLE 2. Twenty Fellows having the right to vote shall constitute a quorum for the transaction of business at Stated or Special Meetings. Fifteen Fellows shall be sufficient to constitute a meeting for literary or scientific communications and discussions.

ARTICLE 3. Upon the request of the presiding officer or the Recording Secretary, any motion or resolution offered at any meeting shall be submitted in writing.

ARTICLE 4. No report of any paper presented at a meeting of the Academy shall be published by any Fellow or Resident Associate without the consent of the author; and no report shall in any case be published by any Fellow or Resident Associate in a newspaper as an account of the proceedings of the Academy without the previous consent and approval of the Council. The Council, in its discretion, by a duly recorded vote, may delegate its authority in this regard to one or more of its members.

ARTICLE 5. No Fellow or Resident Associate shall introduce a guest at any meeting of the Academy until after the business has been transacted, and especially until after the result of the balloting upon nominations has been declared.

ARTICLE 6. The Academy shall not express its judgment on literary or scientific memoirs or performances submitted to it, or included in its Publications.

ARTICLE 7. All proposed Amendments of the Statutes shall be referred to a committee, and on its report, at a subsequent Stated Meeting or at a Special Meeting called for the purpose, two thirds of the ballot cast, and not less than twenty, must be affirmative to effect enactment.

ARTICLE 8. Standing Votes may be passed, amended, or rescinded at a Stated Meeting, or at a Special Meeting called for the purpose, by a vote of two thirds of the members present. They may be suspended by a unanimous vote.

See Chap. ii. art. 5, 8; chap. iii.; chap. iv. art. 3, 4, 5; chap. v. art. 1; chap. vi. art. 1, 2; chap. ix. art. 8.

STANDING VOTES

1. Communications of which notice has been given to either of the Secretaries shall take precedence of those not so notified.

2. Fellows or Resident Associates may take from the Library six volumes at any one time, and may retain them for three months, and no longer. Upon special application, and for adequate reasons assigned, the Librarian may permit a larger number of volumes, not exceeding twelve, to be drawn from the Library for a limited period.

3. Works published in numbers, when unbound, shall not be taken from the Hall of the Academy without the leave of the Librarian.

4. There may be chosen by the Academy, under such rules as the Council may determine, one hundred Resident Associates. Not more than forty Resident Associates shall be chosen in any one Class.

Resident Associates shall be entitled to the same privileges as Fellows, in the use of the Academy building, may attend meetings and present papers, but they shall not have the right to vote. They shall pay no Admission Fee, and their Annual Dues shall be the same as those of Fellows residing within fifty miles of Boston.

The Council and Committees of the Academy may ask one or more Resident Associates to act with them in an advisory or assistant capacity.

5. Communications offered for publication in the Proceedings or Memoirs of the Academy shall not be accepted for publication before the author shall have informed the Committee on Meetings of his readiness, either himself or through some agent, to use such time as the Committee may assign him at such meeting as may be convenient both to him and to the Committee, for the purpose of presenting to the Academy a general statement of the nature and significance of the results contained in his communication.

RUMFORD PREMIUM

In conformity with the terms of the gift of Sir Benjamin Thompson, Count Rumford, of a certain Fund to the American Academy of Arts and Sciences, and with a decree of the Supreme Judicial Court of Massachusetts for carrying into effect the general charitable intent and purpose of Count Rumford, as expressed in his letter of gift, the Academy is empowered to make from the income of the Rumford Fund, as it now exists, at any Annual Meeting, an award of a gold and a silver medal, being together of the intrinsic value of three hundred dollars, as a Premium to the author of any important discovery or useful improvement in light or heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America, or any of the American Islands; preference always being given to such discoveries as, in the opinion of the Academy, shall tend most to promote the good of mankind; and, if the Academy sees fit, to add to such medals, as a further Premium for such discovery and improvement, a sum of money not exceeding three hundred dollars.

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